SEP 14 1929

VOL. 21, NO. 9 SEPTEMBER, 1929

PROCEEDINGS 49TH YEAR

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

PUBLISHED MONTHLY

BY THE

AMERICAN WATER WORKS ASSOCIATION

AT MOUNT ROYAL AND GUILFORD AVENUES, BALTIMORE, MD.

SECRETARY'S OFFICE, 29 WEST 39TH STREET, NEW YORK
EDITOR'S OFFICE, 2411 NORTH CHARLES STREET, BALTIMORE, MARYLAND

Subscription price, $7.00 per annum

Entered as second class matter April 10, 1914 at the Post Office at Baltimore, Md., under the act of August 24, 1912
Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917;
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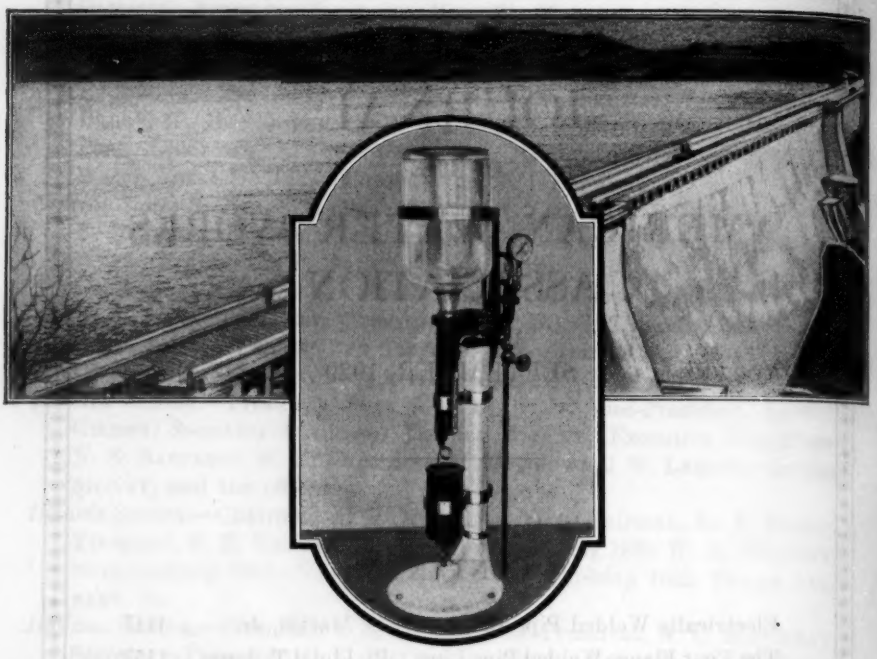

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VOL. 21 SEPTEMBER, 1929 No. 9

ELECTRICALLY WELDED PIPE LINES[1]

BY S. MARTIN, JR.[2]

Before electric welding or any other new process can supersede previous methods of manufacture, it must show two things—first, that it is economically sound and, second, that it can equal or better the physical results obtained by preceding methods. Electric welding has demonstrated its superiority in both of these requirements.

Since the field of application for electric welding is so broad, covering airplanes, buildings, automobiles, oil, water and gas pipe lines, along with the manufacture of all kinds of machinery, we will limit the scope of this paper to one particular application—namely, electrically welded steel water lines.

The economics of a water line include a great deal more than first cost. Such factors as leakage, maintenance, life of the pipe, continuity of operation and safety must be considered. All of these form a basis of comparison on which electric welded pipe should be required to compete with gas welded, riveted, lock bar or any other design or construction.

Let us compare, for example, riveted pipe with welded pipe. It is self-evident that the riveted joint can not economically be made to equal the plate strength, whereas with welding the joint can be made to equal the plate strength. Another advantage is that truly

[1] Presented before the Toronto Convention, June 27, 1929.

[2] Industrial Engineering Department, General Electric Company, Schenectady, N. Y.

circular welded pipe lends itself more readily to joining than riveted pipe with an offset along the line of riveting. Furthermore, there are no rows of rivets to interfere with the carrying capacity of the line. It has been claimed that the welded pipe has 10 per cent higher carrying capacity than a riveted pipe of equal diameter. Referring to the Mokelumne Pipe Line, the original specifications called for riveted construction with maximum inside diameter of 68 inches and material up to $\frac{9}{16}$- and $\frac{5}{8}$-inch in thickness, while as a welded line a maximum thickness of material required was $\frac{1}{2}$-inch and the corresponding inside diameter was 65 inches. As far as leakage is concerned, there is none with a welded line. There is no such thing as caulking the seams in a welded line and this removes the possibility of leaks as the line ages.

Much can be said about first cost of an arc welded line, but there is nothing more convincing than actual cost figures. It has been successfully demonstrated that a completely arc welded line can be installed at 90 per cent of the cost of a riveted line and sections of pipe themselves fabricated for 75 per cent of the cost of riveted pipe. The successful bidder on the Springfield, Mass., pipe line was 6 per cent lower than the lowest all riveted construction bid. This line had welded longitudinal seams and riveted girth seams.

PRELIMINARY TESTS

Before bids could be submitted or any active work done on water pipe lines, as regards electric welding, much experimental work had to be accomplished, in order to determine the proper procedure which would give thoroughly reliable and uniform results.

Probably the best way to familiarize ourselves with the welding of a pipe line is to take an example of a successful installation and follow it to completion. The example selected is the process employed for fabricating the pipe for the above mentioned Springfield pipe line from Provin Mountain Reservoir to the City of Springfield, Mass.

Test plates 48 inches long by 9 inches wide by $\frac{1}{2}$-inch thick were used to make the tests. They were of ASTM A78 Grade B steel and had the following approximate analysis:

Carbon—not over 0.20 per cent.
Manganese—0.35 to 0.60 per cent.
Phosphorus—not over 0.06 per cent.

Sulphur—not over 0.05 per cent.
Tensile strength—minimum 50,000 pounds per square inch.
Yield point—0.5 per cent tensile strength and in no case less than 27,000 pounds per square inch.
Elongation in 8 inches—25 per cent.

These test plates were beveled in accordance with figure 1, as this type of groove allowed complete penetration. The plates were then butted together and a weld was made on the back of the plates using $\frac{3}{16}$-inch G-E Type "F" welding electrode and approximately 20 volts or less with current of 200 to 220 amperes. This bead was run at about 5 inches per minute by hand or 10 inches per minute with the automatic. Penetration was over half way through the $\frac{3}{16}$-inch thick material under the groove, but did not penetrate all the way through.

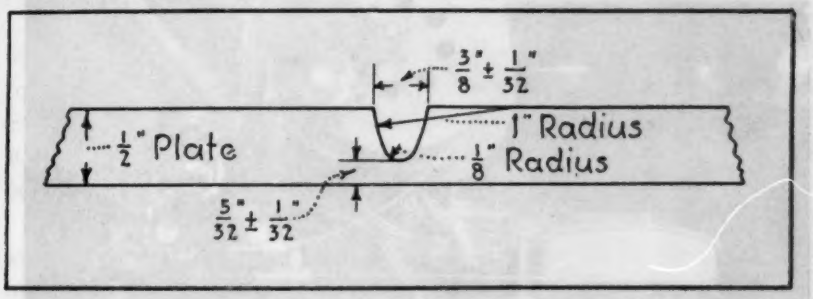

FIG. 1. SPECIMEN TEST PLATE

The weld was then made in the groove using the multiple arc process. This process employs two arcs, one following about 8 inches behind the other. The two automatic welding heads, which feed the wire, are mounted on a single motor driven adjustable speed travel carriage (figure 2), which moves the heads along the work at the proper welding speed. The first arc used used $\frac{1}{8}$-inch G-E Type "F" electrode and 16 to 18 volts at approximately 300 amperes, while the second arc used $\frac{3}{16}$-inch G-E Type "B" electrode and 20 to 22 volts at approximately 350 amperes. The first arc of the multiple arc process filled the groove to within $\frac{1}{16}$ to $\frac{1}{8}$ inch of the top and was practically flat across. The second arc filled the groove and produced a bead on the top of about $\frac{3}{4}$-inch wide by $\frac{1}{16}$-inch to $\frac{1}{8}$-inch. The welding was done at a speed of approximately $5\frac{1}{2}$ inches per minute.

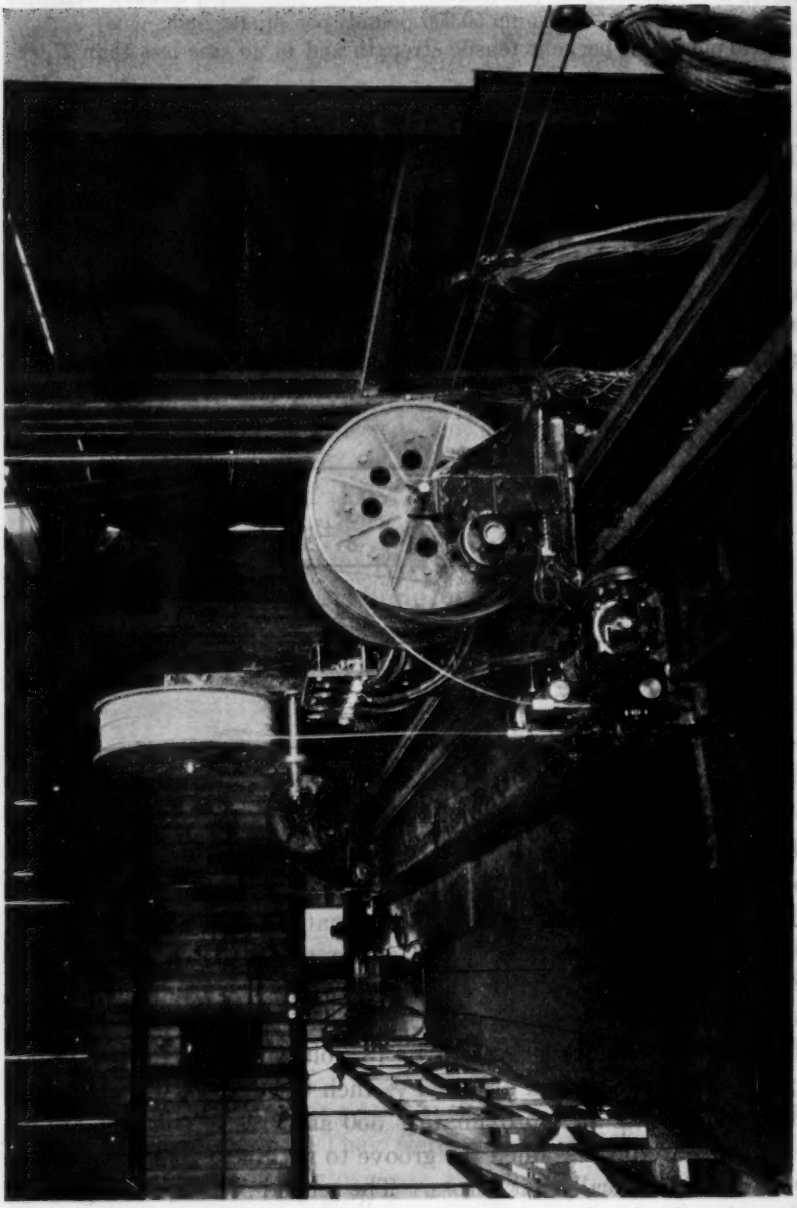

FIG. 2. MULTIPLE ARC WELDERS WITH TRAVEL CARRIAGES MOUNTED ON 36-FOOT PIPE WELDING MACHINE

The following table shows chemical analysis of the two welding electrodes:

CONSTITUENT	G-E TYPE "B"	G-E TYPE "F"
Carbon	0.10 max.	0.13 to 0.18
Manganese	0.25 to 0.45	0.40 to 0.60
Sulphur	0.045 max.	0.03 max.
Phosphorus	0.03 max.	0.045 max.
Silicon	Trace	Trace

Type "F" is a solid wire to which a special treatment is given to insure uniform flowing quality. Type "B" has a center metallic core surrounded by a layer of flux, the whole being encased in a metallic sheath.

The welded plates were then cut into strips 1½ inches wide. Some of these strips were tested in tension, others were bent around a pin to check ductility. The results of the tensile test indicated 100 per cent tensile strength of the weld or every specimen broke in the steel. Most of the specimens broke at a value over 60,000 pounds per square inch.

Figure 3 shows very clearly the metal deposited by the three arcs and the zone in the plate stock into which the heat of the weld has penetrated. Photomicrographic studies of the grain structure of the steel in the weld and adjoining plates show total lack of a definite line marking the transition from the weld to the plate, and no evidence whatever of any injury to the plate owing to the heat of the weld.

MANUFACTURE OF PIPE

The pipe for the Springfield water line was made in 30-foot lengths from two 30-foot plates which were bent into half circles and automatically arc welded together. Some consideration was given to welding of the girth joints in the field, but because of considerable opposition, it was decided not to do this on this particular job, and the 30-foot sections were riveted together in the field. To provide for this, the plates were sheared so that the pipe diameter increased slightly from one end to the other, thereby permitting the small end of one section to fit into the large end of the next section an amount required for the riveted joint.

The first operation in the manufacture of the pipe after the flat

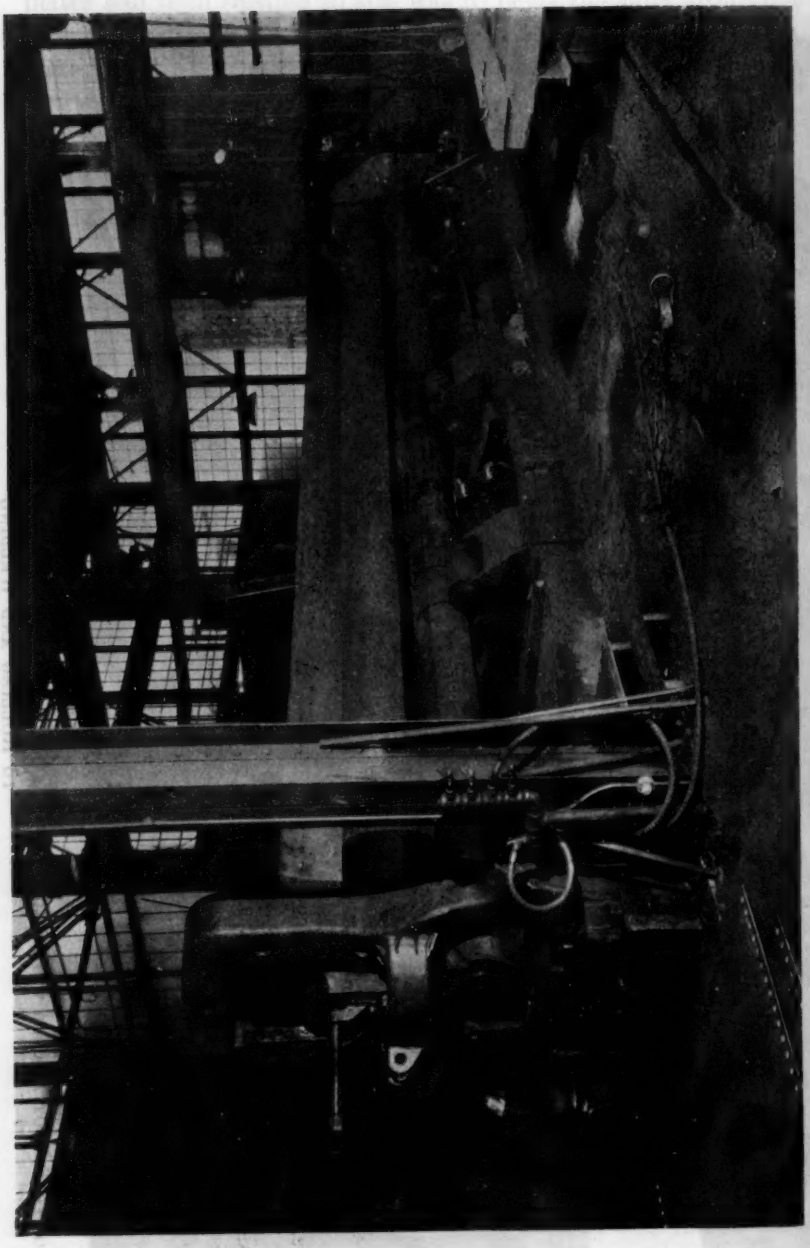

FIG. 5. 36-FOOT BENDING ROLL SHOWING THE ROLLING OF A SECTION OF PIPE PREPARATORY TO ASSEMBLING AND AUTOMATICALLY ARC WELDING

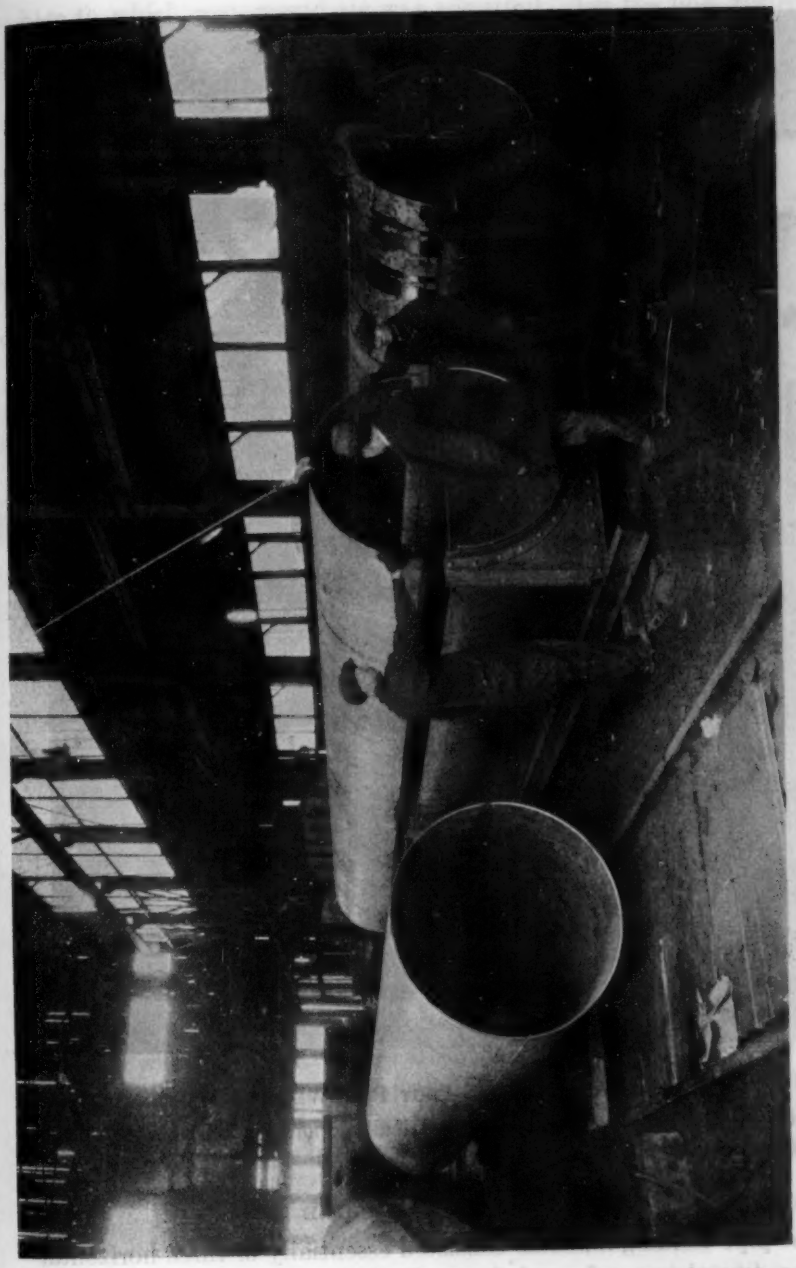

FIG. 6. ASSEMBLING BY TACK WELDING 2 HALVES OF A 30-FOOT BY 48-INCH DIAMETER PIPE BEFORE GOING TO AUTOMATIC WELDER

plates had been sheared to size was to bevel the sides accurately as shown in figure 1. This is done simultaneously on two plates on the plate planer, as shown in figure 4. On each plate two lines were then scribed, parallel to the upper edge of the bevel and $\frac{3}{4}$-inch from it.

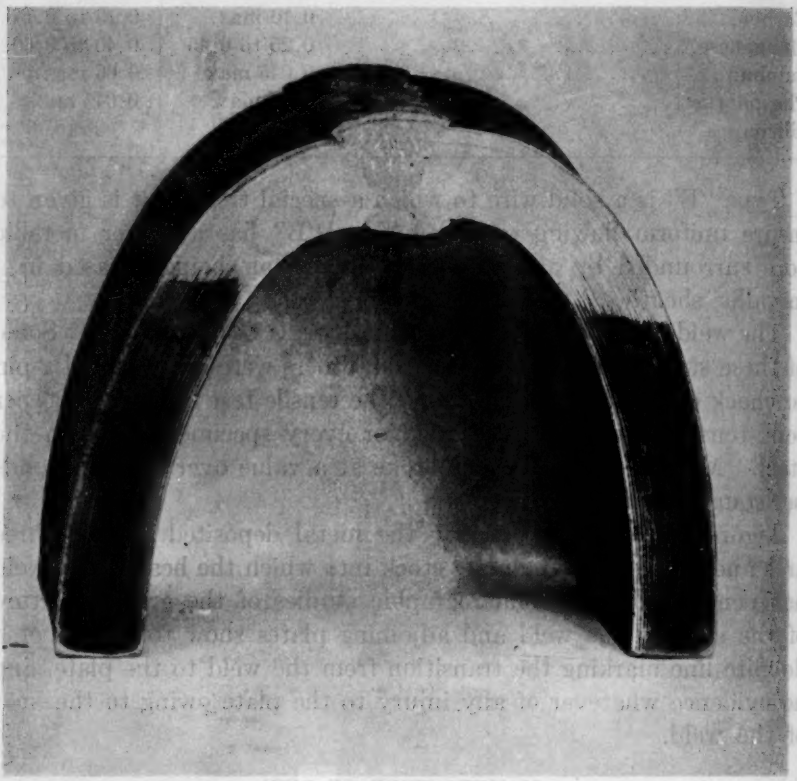

FIG. 3. MACROGRAPH OF DOUBLE ARC WELD ON $\frac{1}{2}$-INCH A.S.T.M. SPECIMEN A78 GRADE B PLATE WITH BEAD ON BACK OF JOINT

The plate was then taken to the bending rolls, figure 5, and by means of a special jig, the 30-foot edges were bent to the proper radius. The whole section was then formed into a true half circle. Next the two halves of the pipe were placed in a specially designed frame, figure 6, and tack welded together approximately every 16 inches on the inside by hand. The pipe section was then removed and a complete bead run inside by hand. It is then ready to be placed in the welding machine as shown in figure 7.

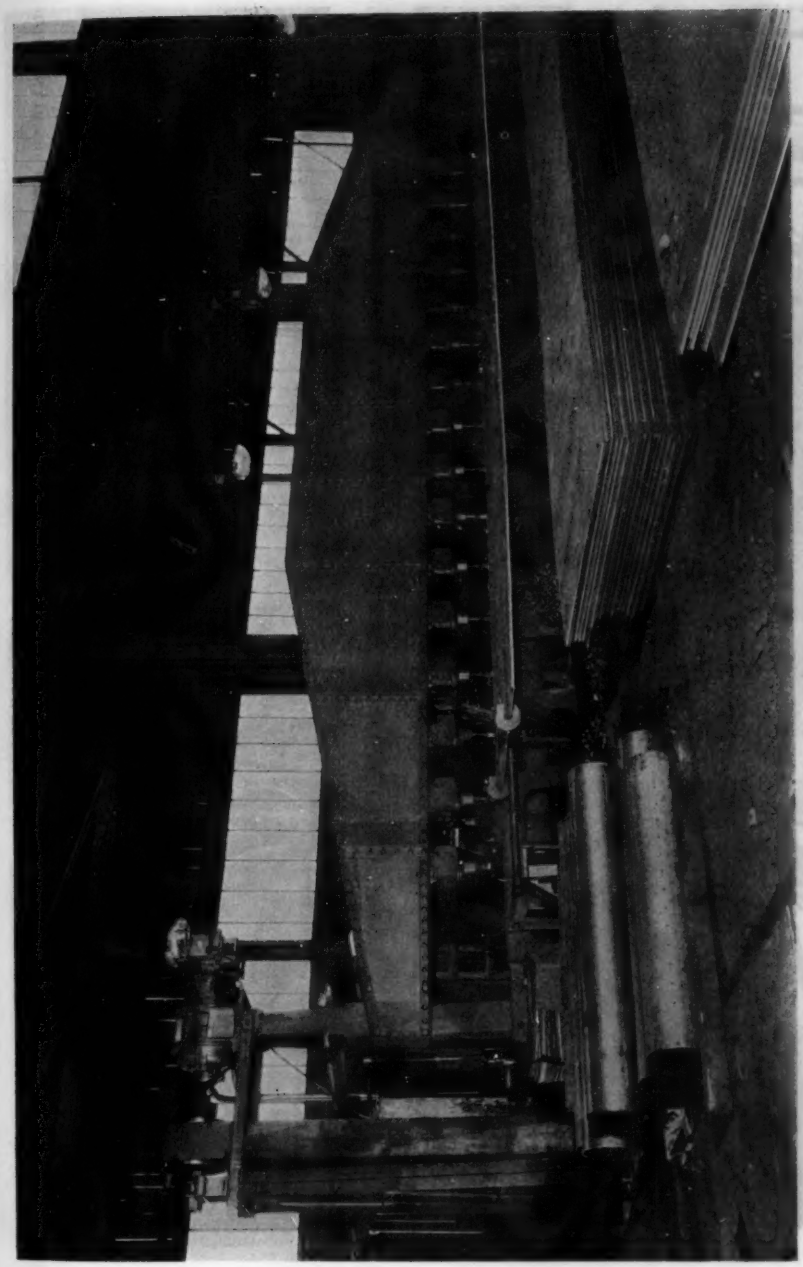

FIG. 4. 36-FOOT PLANER WITH 2 30-FOOT PIPE PLATES CLAMPED IN POSITION FOR PLANING U BEVEL PREPARATORY TO ROLLING AND WELDING

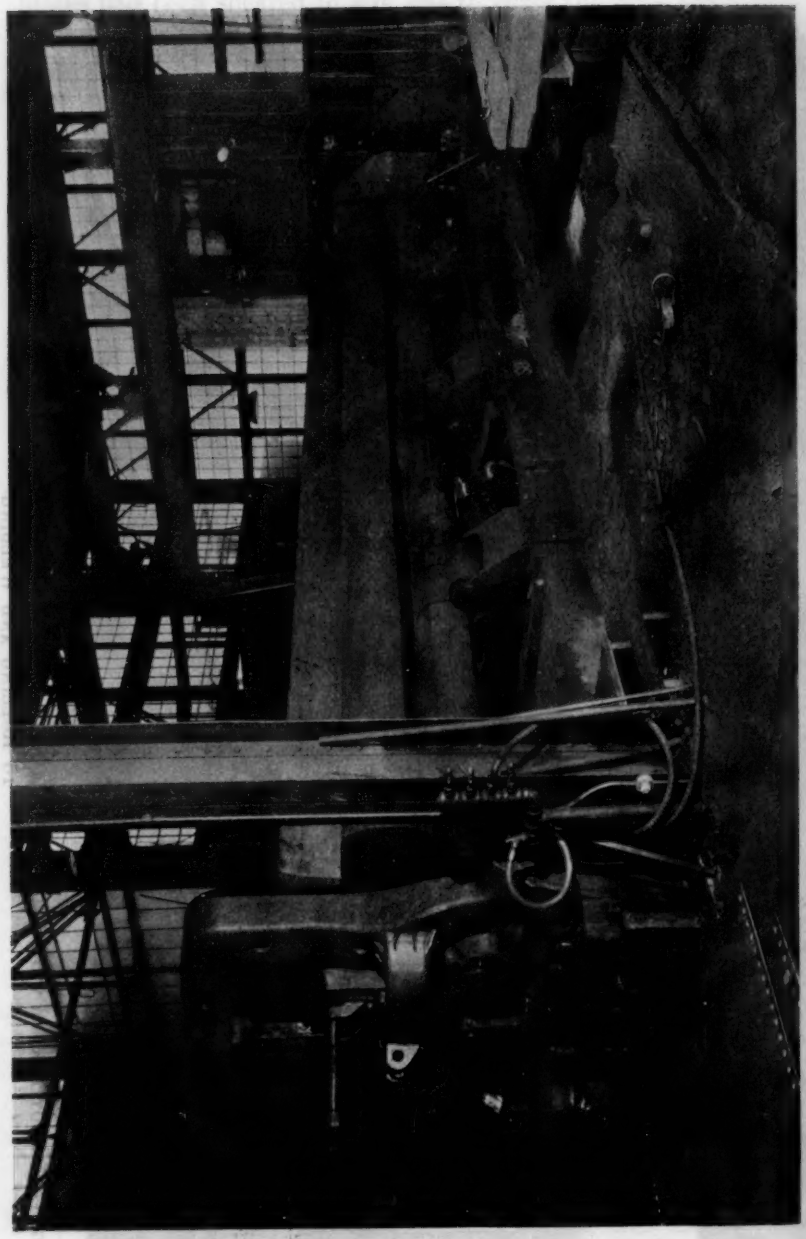

FIG. 5. 36-FOOT BENDING ROLL SHOWING THE ROLLING OF A SECTION OF PIPE PREPARATORY TO ASSEMBLING AND AUTOMATICALLY ARC WELDING

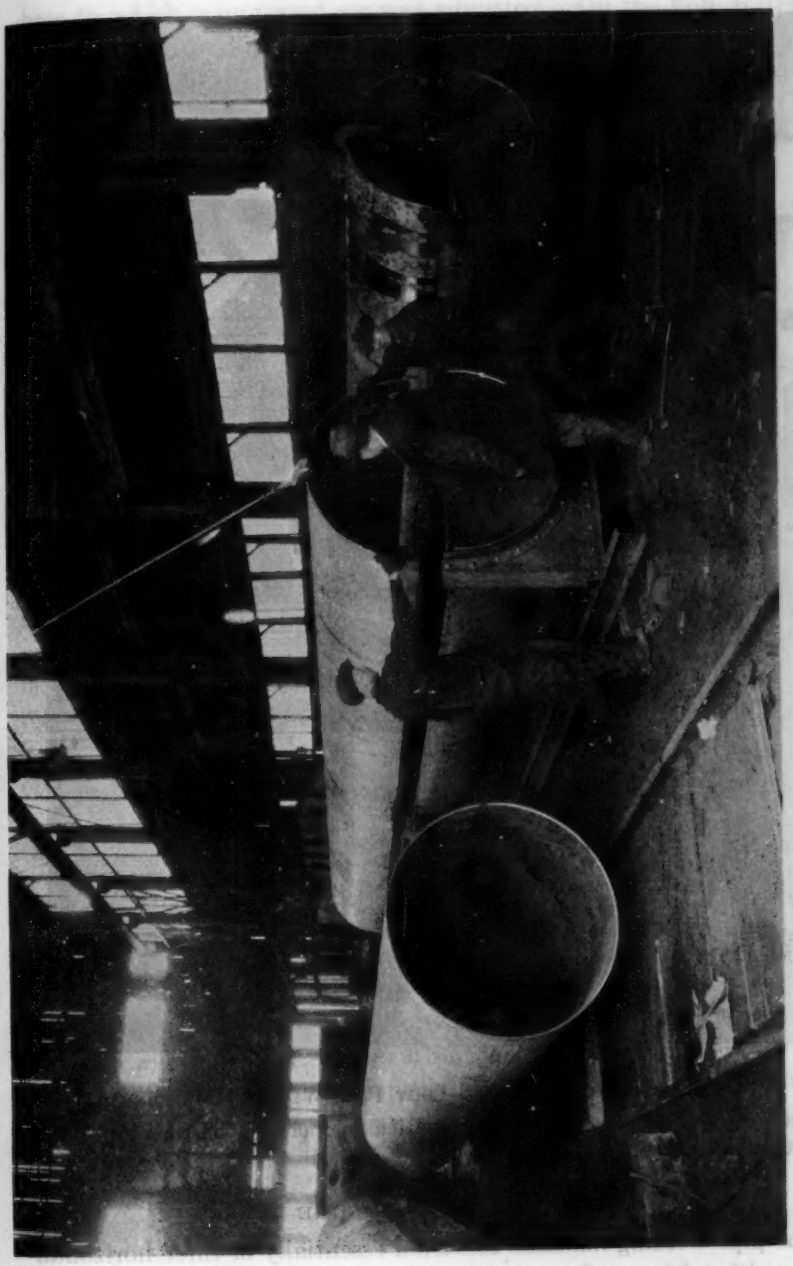

FIG. 6. ASSEMBLING BY TACK WELDING 2 HALVES OF A 30-FOOT BY 48-INCH DIAMETER PIPE BEFORE GOING TO AUTOMATIC WELDER

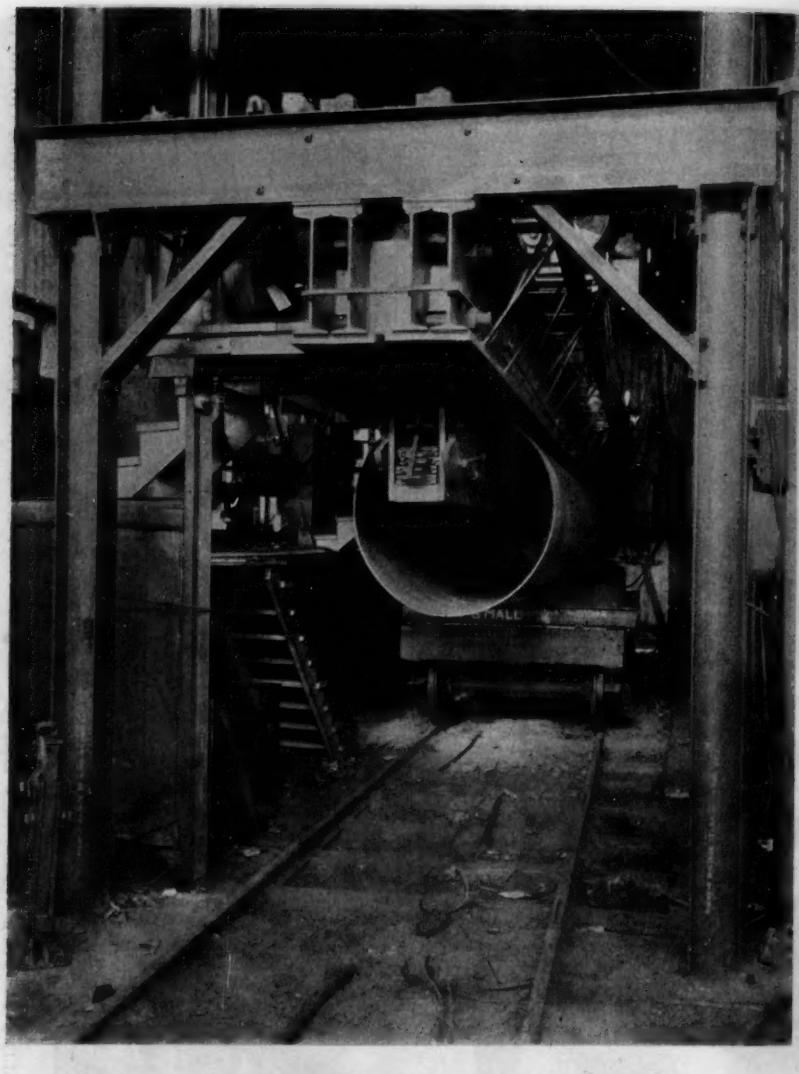

FIG. 7. LOADING END OF 36-FOOT PIPE WELDING MACHINE

Shows lower supporting and pneumatically operated backing up beam locked in position for welding.

PIPE WELDING MACHINE

The pipe welding machine consisted essentially of three horizontal beams, two above and one below. Enclosed in the lower beam and extending throughout its full length were several sections of fire

hose to which compressed air was admitted. On the hose rested a series of plungers, which in turn supported a "backing bar," the latter being fitted with a flat copper chill bar approximately 2 inches wide. Application of compressed air caused the hose to expand, thereby raising the plungers and the copper strip in the backing bar was pushed up against the under side of the joint at a pressure of 200 pounds or more per running inch. The backing bar was also provided with an insulated conductor which formed part of the return circuit for the welding current. By shunting the proper current through this bar when the pipe was being welded, the magnetic disturbances of the arc were very effectively controlled.

To the lower side of the upper beams of the machine were attached two copper jaws spaced approximately 2 inches apart and the pipe was placed in the machine so that the joint to be welded was located centrally between these two copper jaws and directly over the copper strip in the backing bar.

Figure 2, as explained previously, shows the double head automatic travel carriage for the welding after the plates have been properly clamped in the welding machine. Two such carriages were mounted on the 30 foot machine. This meant that each one of these did 15 feet of the pipe and reduced the welding time to 50 per cent of that required for one carriage. A third such double head travel carriage is being contemplated for a further saving of welding time on future operations.

After one seam was welded, the pneumatic clamp was released and the pipe rotated to bring the second joint in position.

SPEED OF WELDING—ELECTRODE—POWER CONSUMPTION

The speed of welding attained by the multiple arc process with two welding heads on $\frac{1}{2}$-inch plate was approximately 28 feet per hour. Using the welding conditions formerly outlined, about one pound of electrode was deposited. The current for each pair of welding heads was supplied from a 1000 ampere-1 hour rated constant potential welding generator driven by an induction motor. The power consumed was approximately 2.15 KW hours per foot of weld on $\frac{1}{2}$-inch thick plate.

TESTING

At the request of the inspector, check test plates about 12 inches long and a total width of 16 inches, with a bevel as specified for the

pipe joints, were placed at each end of the pipe seam and welded under the same conditions as the pipe itself. These plates were then cut into specimens. Some of these were tested in tension, others bent and still others were put in a fatigue testing machine.

The pipe itself was given a thorough visual inspection to determine possibility of holes, lack of fusion and reinforcement. The weld was reinforced—i.e., its height above the surface of the plate was usually from $\frac{1}{16}$ to $\frac{1}{8}$ inch. The minimum and maximum values permitted by good practice are $\frac{1}{32}$ and $\frac{3}{16}$ inch, respectively. The weld bead must also be central between the scribed lines on the plate at each end of the joint, allowing a maximum variation of $\frac{1}{16}$ inch from the center. The width of the weld bead was measured and its over-all width was not permitted to be less than $\frac{9}{16}$ inch. Any holes which were seen on the top surface of the deposited metal were carefully chipped and if they extended below the surface of the plate, the spot was rewelded by hand. The edges of the bead were also examined to see that the weld metal was thoroughly fused along the top of the plate. Any cracks or hollow spots were chipped and rewelded by hand.

After the welded pipe had been given a careful visual inspection and any defects rewelded, it was placed in the testing machine, figure 8, and subjected to the following hydrostatic pressures in pounds per square inch.

	THICKNESS OF PIPE			
	5/16 inch	3/8 inch	7/16 inch	1/2 inch
66 inch pipe		160		
54 inch pipe	135	160	187	213
48 inch pipe			210	240
36 inch pipe				320

In this particular installation the rivet holes were then punched in each end of the pipe, after which it was thoroughly cleaned and dipped vertically in an electrically heated tank of coal tar pitch varnish, figure 9. The pipe was submerged in the bath long enough to heat the metal uniformly to the temperature of the bath. It was then removed and suspended in a vertical position until the coating had drained and set.

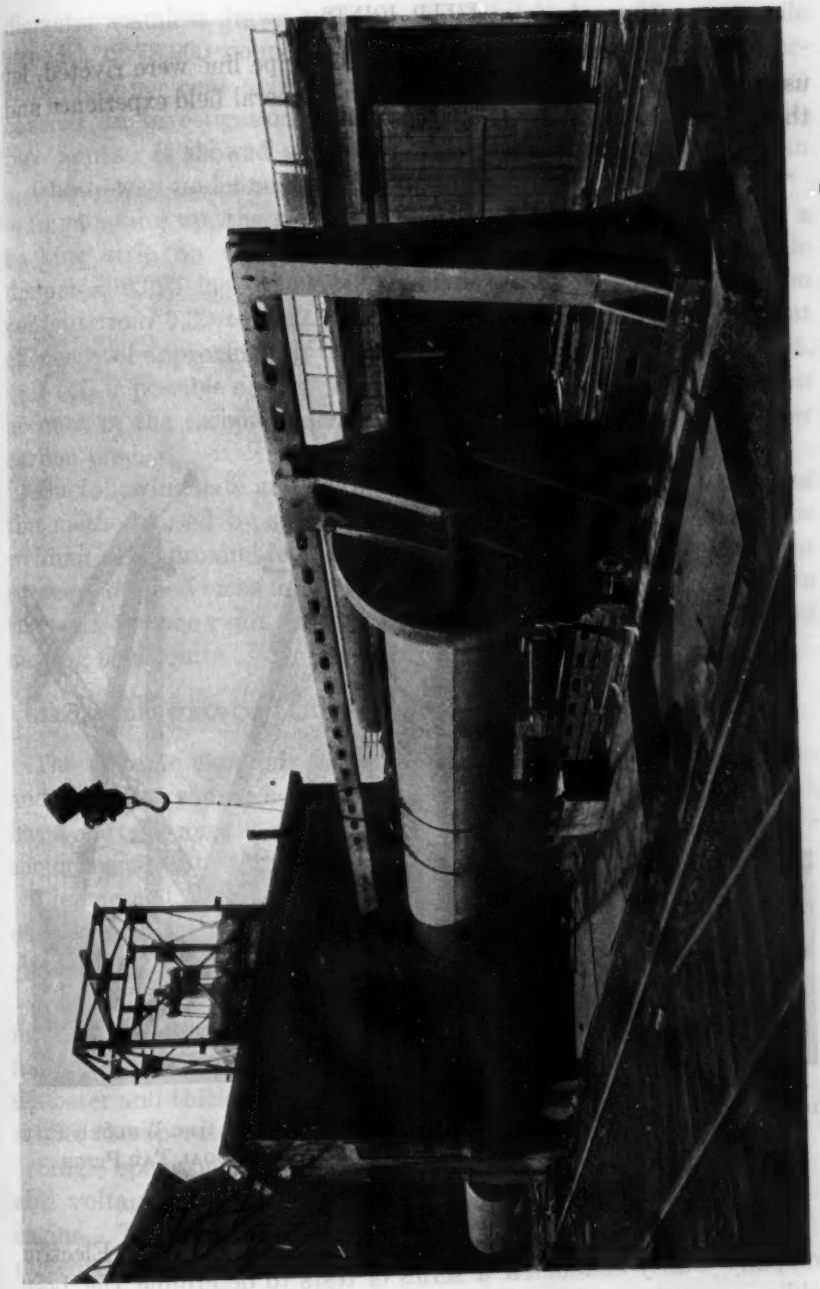

FIG. 8. HYDRAULIC TESTING MACHINE WITH 30-FOOT LONG, 48-INCH DIAMETER PIPE IN PLACE

FIELD JOINTS

Since the girth joints of the Springfield pipe line were riveted, let us look to another line or, better still, to general field experience and the results of tests.

FIG. 9. LOWERING A 30-FOOT BY 48-INCH AUTOMATICALLY ARC WELDED PIPE INTO AN ELECTRICALLY HEATED VERTICAL TANK OF COAL TAR PITCH VARNISH TO GIVE THE PIPE A PROTECTIVE COATING

Last fall the National Tube Company and the General Electric Company jointly conducted a series of tests to determine the best welding procedure for welding girth seams of $10\frac{3}{4}$ inches outside

diameter seamless drawn tubing. This pipe had an ultimate tensile strength of 78,000 pounds per square inch, a carbon content averaging 0.36 per cent and a wall thickness of 0.395 inch. This report covered an investigation of metallic arc welding of butt type, girth pipe joints. It showed what may be expected from welds made in a definite way under competent supervision.

In summing up, the report states the double pass method with a backing strip on the inside of seamless pipe $10\frac{3}{4}$ inches outside diameter, 0.395 inch thick, $43\frac{3}{4}$ pounds per foot, having a carbon content from 0.32 to 0.42 per cent, will produce an average joint efficiency of approximately 90 per cent with the lowest at 85 per cent.

If this is possible on high carbon pipe, which is difficult to weld on account of the carbon content, consider the possibilities on a lower carbon pipe.

The following data are offered as material obtained from a study of the methods used by successful welding contractors in the electric welding of approximately 1250 miles of pipe lines. The excellent success obtained on so many miles of lines is positive proof that when the work is done right, electric welding is by far the best method of making field joints.

ELECTRODE WELDING CURRENT—SOURCE OF WELDING CURRENT

The metallic electrode for welding the commercial grades of iron and steel pipe should be of a high grade, low carbon steel wire which has a carbon content of 0.20 per cent or less. The electrode wire should be cut into convenient lengths of 14 to 18 inches.

Commercial thickness of pipe, 6 to 20 inches in diameter, will require two beads, using $\frac{5}{32}$-inch diameter electrode on the first bead and $\frac{3}{16}$-inch on the second.

On the first bead with $\frac{5}{32}$-inch electrode the welding current will range from 140 to 170 amperes, and on the second bead with $\frac{3}{16}$-inch electrode, from 160 to 200 amperes. In general, the greater diameter and thickness of pipe will require the higher current. The skill of the operator will also govern somewhat the current used.

Single operator welding machines are available, consisting of variable voltage type welding generator directly connected to a gasoline engine. They should be selected with sufficient capacity to provide the current requirements with continuous welding and with further regard to arc stability, making for ease of welding, lightness of weight,

facility of transportation along the line, and ruggedness of construction to withstand rough handling in service.

There are many different types of joints such as (1) butt; (2) bell and spigot with and without a welding dam; (3) expansion joint and other modifications of all of these. Usually different contractors have different methods of distributing their crew, depending on the type of joint which, of course, has some influence on the welding procedure. For this reason, it is not feasible to include different procedures at this time.

In doing field welding, qualification of welders is very important. It is covered rather completely in the November, 1928, issue of the Journal of the American Welding Society. Another important feature of field welding is the inspection of welds and this is covered in the January, 1929, issue of the Journal of the American Welding Society.

PARTIAL LIST OF INSTALLATIONS

In the vicinity of San Francisco, there have been several water pipe lines installed in the past few years in which arc welding has played an important part:

1. In the year 1924 the Gordon Valley Line for City of Valleji, 22 miles all arc welded, 22- and 24-inch pipe.

2. In the year 1925 the Mokelumne River Project. 90 miles of shop welded 54- to 65-inch pipe.

3. In the year 1926 Marin Municipal Water District, 7½ miles of 26- and 30-inch shop welded pipe.

4. In the year 1926 East Bay Water Company, several miles of arc welded pipe furnished by 3 Bay District fabricators for installation near Mills College, Oakland.

5. Year 1927—Spring Valley Water Company, welded pipe for San Francisco installation.

In the East, besides the Springfield pipe line mentioned as an example in this paper, there have been other lines welded or in the process of welding in New York City and Boston. These cover the two extremes of North America and there have been many others in between these points.

CONCLUSION

Some advantages gained by the electric welding of pipe as compared with other methods of manufacture are a very substantial reduction

in cost, and a superior finished product. The reduction in cost is secured not alone by the decreased weight of steel required, but also by a reduction in the cost of actual work of fabricating the pipe.

Owing to the smooth interior of the welded pipe as compared with the riveted pipe, the resistance to flow is decreased. The circumferential or girth joints are made more easily with welded pipe because of uniform wall thickness, whereas with riveted pipe the wall is of double thickness at the riveted joints. The joining of the ends of pipes made by the lock bar process is rather difficult owing to the presence of the bar.

Arc welded pipe is also invading the field of lap welded pipe produced by the lap weld mills because of the fact that the wall of the latter is thick and often the pressures are such that much lighter arc welded pipe can be used with consequent reduction in the cost of the line.

TENTATIVE SPECIFICATIONS

As an addendum, attached is a copy of a tentative set of specifications for procedure control for welding, inspection and test of welded pipe for municipal water pipe lines.

[TENTATIVE]

PROCEDURE CONTROL FOR WELDING, INSPECTION AND TEST OF WELDED PIPES FOR MUNICIPAL WATER PIPE LINES

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1. Thickness of plate
2. Plate material
3. Preparation of plate
4. Welding the joints
5. Visual inspection of welds
6. Physical tests
7. Acceptance tests
   a. Hydrostatic
   b. Check
8. Marking

PROCEDURE CONTROL

1. Thickness of plate

These specifications shall be understood to cover the welding, inspection, and test of the following thicknesses (in inches) of plate material for municipal water pipe lines:

$\frac{3}{16}$ $\frac{1}{4}$ $\frac{5}{16}$ $\frac{3}{8}$ $\frac{1}{2}$

2. Plate material

The plate material used for pipe lines to which these specifications shall apply shall be good welding steel, such as A.S.T.M. A-78 Grade B or its equivalent.

3. Preparation of the plate

(a) The edges of the plate to be welded shall be accurately machined, beveled and welded as herein specified:

(1) $\frac{3}{16}$ inch plate H-3839198 Figs. 1 and 2.
(2) $\frac{1}{4}$ inch plate H-3839197 Figs. 1 and 2.
(3) $\frac{5}{16}$ inch plate H-3839197 Figs. 1 and 2.
(4) $\frac{3}{8}$ inch plate H-3839197 Figs. 3 and 4.
(5) $\frac{1}{2}$ inch plate H-3839197 Figs. 3 and 4.

(b) The above specified bevels are mandatory with the following exception:

(1) Other bevels and forms of weld may be used at the discretion of the manufacturer provided he can produce the results as herein specified to the satisfaction of the Purchaser's inspector.

(c) After beveling a line shall be deeply scribed on each plate parallel to the beveled edge and $\frac{3}{4}$-inch from it.

(d) The beveled plate shall be rolled to form a true circle with no flat sections along the beveled edges.

(e) The pipe section shall be tack welded with the beveled edges properly spaced and the section will then be ready for welding.

In the welding operation care must be taken to insure complete fusion of the plate edges underneath the tack welds.

4. Welding the joints

(a) Wherever required as specified in paragraph 3, the joints shall first be arc welded on the inside. This may be done by hand using a welding current of approximately 175 to 200 amperes and holding an arc of approximately 20 volts. This weld shall be made at a speed of approximately 6 inches per minute travel and the bead shall be between $\frac{3}{8}$- and 1-inch wide at the plate surface.

This weld may also be made by the automatic arc process using approximately from 280 to 320 amperes and an arc voltage of approximately 20 at a travel speed of approximately 10 inches per minute. The bead shall be between $\frac{1}{4}$- and $\frac{3}{8}$-inch wide at the plate surface.

(b) The outside weld on the joints shall be made by what is known as the "multiple automatic arc" process, i.e., two automatic welding beads mounted on and propelled by a single carriage with the following exceptions:

(1) The outside weld of either the $\frac{3}{16}$- or the $\frac{1}{4}$-inch plate may be made by what is known as the "single automatic arc" process, i.e., one automatic welding head mounted on and propelled by a single travel carriage.

(c) The following approximate welding conditions shall be used for the outside welds with the bevels as already specified. The manufacturer shall be allowed to use other welding conditions and forms of welds than those speci-

fied herein provided he shall obtain the results specified herein to the satisfaction of the Purchaser's inspector.

$\frac{3}{16}$-inch plate

Electrode—$\frac{3}{16}$-inch diameter.
Current—275 to 325 amperes.
Voltage at arc—18 to 22.
Speed of travel—8 to 12 inches per minute.

$\frac{1}{4}$-inch plate

Electrode—$\frac{3}{16}$-inch diameter.
Current—275 to 325 amperes.
Voltage at arc—18 to 22.
Speed of travel—5 to 8 inches per minute.

$\frac{5}{16}$-inch plate

1st arc:

Electrode—$\frac{1}{4}$-inch in diameter.
Current—250 to 300 amperes.
Voltage at arc—16 to 18 volts.

2nd arc:

Electrode—$\frac{3}{16}$-inch in diameter.
Current—300 to 350 amperes.
Voltage at arc—20 to 22 volts.
Speed of travel—6 to 10 inches per minute.

$\frac{3}{8}$-inch plate

1st arc:

Electrode—$\frac{1}{4}$-inch in diameter.
Current—250 to 300 amperes.
Voltage at arc—16 to 18 volts.

2nd arc:

Electrode—$\frac{3}{16}$-inch in diameter.
Current—300 to 350 amperes.
Voltage at arc—20 to 22 volts.
Speed of travel—6 to 8 inches per minute.

$\frac{1}{2}$-inch plate

1st arc:

Electrode—$\frac{1}{4}$-inch in diameter.
Current—275 to 325 amperes.
Voltage at arc—16 to 18 volts.

2nd arc:

Electrode—$\frac{3}{16}$-inch in diameter.
Current—325 to 375 amperes.
Voltage at arc—20 to 22 volts.
Speed of travel—4 to 6 inches per minute.

(d) Welding wire of such welding characteristics and analysis shall be used as will produce the results specified herein.

(e) The pipe section shall be placed in a suitable welding machine provided with a magnetic control circuit for the purpose of reducing magnetic disturbances of the arc or arcs when necessary. The welding machine shall be provided with suitable means for backing up the weld so as to secure 100 per cent penetration where the initial weld on the back side of the joint is not required.

5. Visual inspection of welds

(a) The height of the weld bead over the surface of the plate shall be measured and in no case shall a weld be accepted where the height is less than $\frac{1}{32}$-inch above the plate surface. Welds where the height of bead is over $\frac{1}{8}$-inch are not desirable, and should not be accepted where the height is over $\frac{3}{16}$-inch.

(b) The width of the weld bead shall be measured and its overall width shall not be less than one and one-half times the width of the bevel.

(c) The weld bead shall be central between the scribed lines on the plate at each side of the joint. A maximum variation from the center as given below shall be allowed: (See H-4306738)

Width of Weld Bead	*Allowable Variation*
$1\frac{1}{2}$W	0.17W
$1\frac{3}{4}$W	0.25W
2W	0.30W

(d) The top of the weld bead shall be smooth and uniform. If any holes appear on the top or side of the bead they shall be chipped and if they extend below the surface of the plate, the hollow spots shall be rewelded by hand. Holes which do not extend below the surface of the plate need not be rewelded.

Any projection caused by oxide on top of the weld bead shall be chipped off flush with the bead. If a hole appears, it shall be treated as just specified.

(e) The edges of the weld bead shall be inspected to determine that the weld metal is thoroughly fused along the top of the plate. There shall be no hollow spots or evidence of overlap of the weld on the plate surface. If such evidence appears, a light chipping may be used to determine the extent of the defect. After chipping, if the width of the bead has decreased below the limit herein specified or the hollow spot extends below the surface of the plate, they shall be rewelded.

(f) A standard test specimen shall be made up in accordance with these specifications from a welded plate which has been welded and tested in accordance with these specifications.

This test specimen shall be used as a guide for the inspector in making a visual inspection of the welded pipe sections. With this specimen as a guide, the inspector shall examine the welded pipe sections to determine that the weld conforms to the requirements of these specifications.

6. Physical Tests

(a) Check test plates 12 inches long and having a total width of 16 inches shall be placed at each end of every third section of pipe in the welding machine, in such a manner that the joints in the test plates are exactly in line

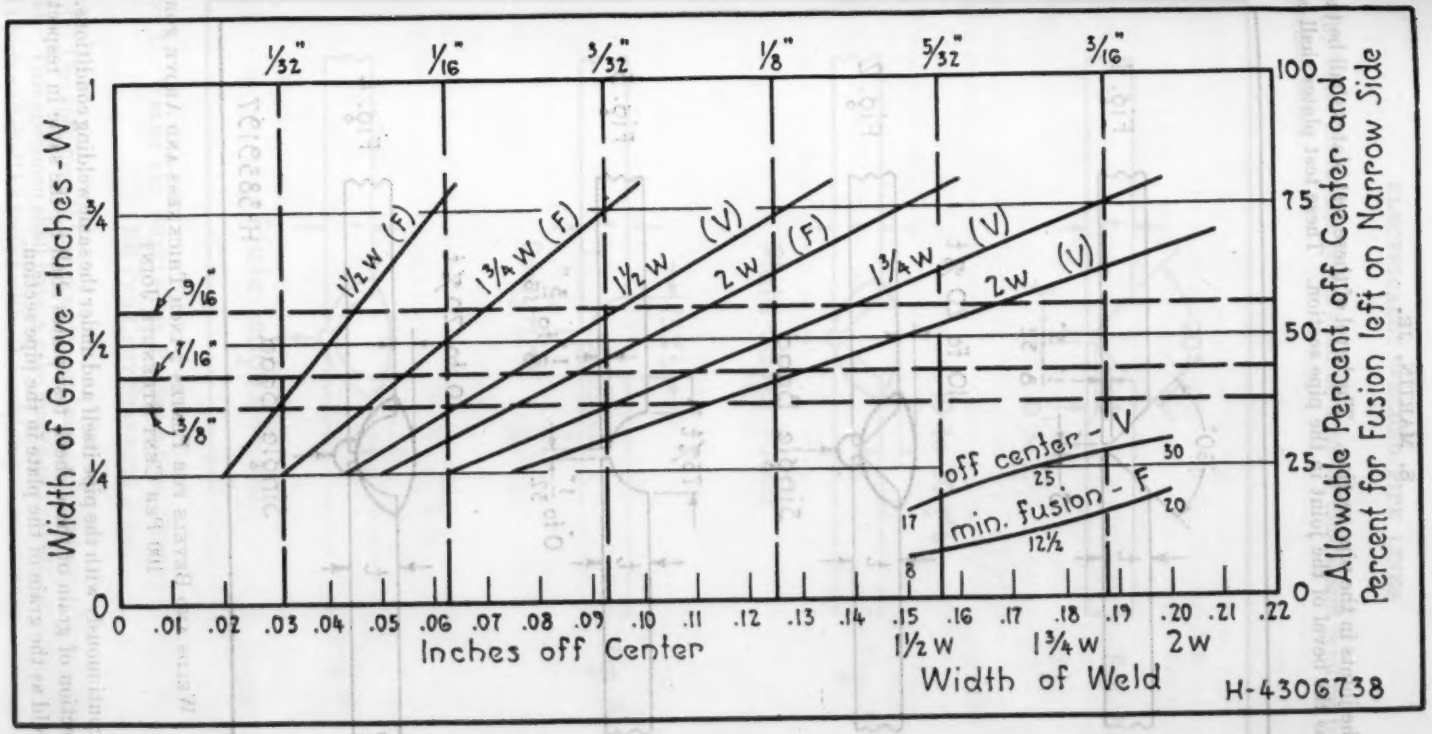

FIG. A. ALLOWABLE VARIATIONS FROM CENTER OF WELD BEADS ON BUTT JOINTS

with the joints in the pipe section. The bevel of these test plates shall be the same as the bevel of the joint in the pipe section. These test plates shall be

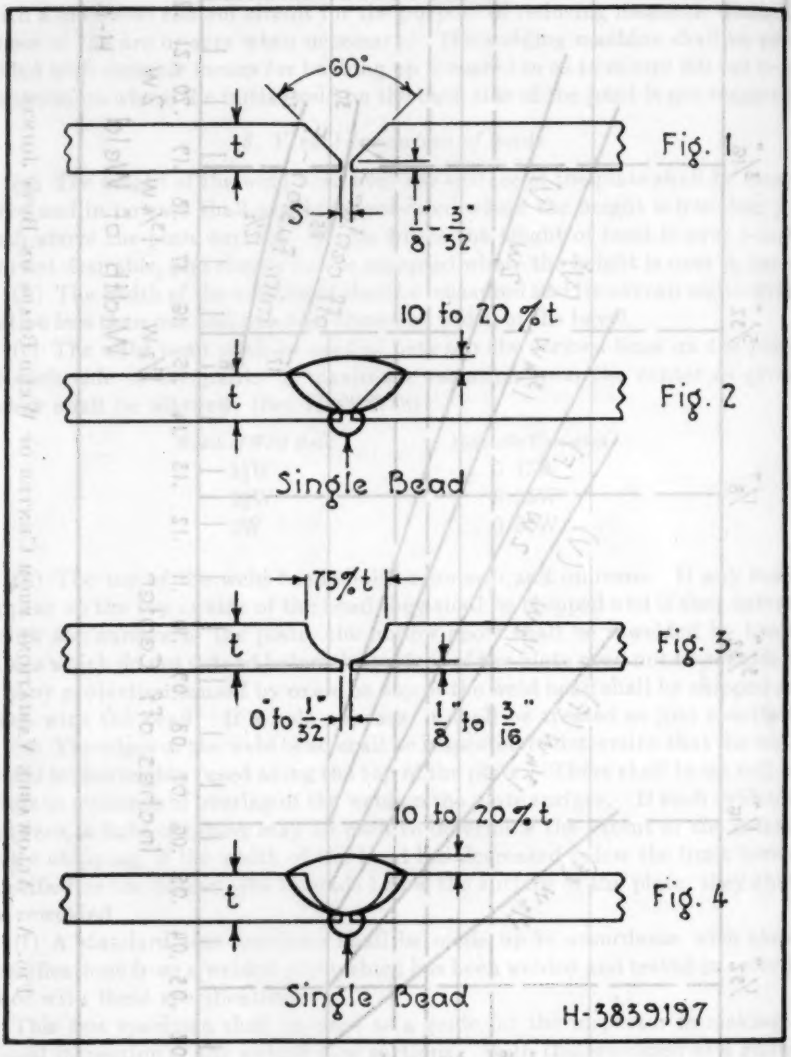

FIG. B. WELDS AND BEVELS FOR PLATES ¼-INCH THICKNESS AND ABOVE FOR 100 PER CENT STRENGTH JOINT

welded continuously with the pipe itself and under the same welding conditions. The direction of grain of these check test plates shall be the same in respect to the weld as the grain of the plate in the pipe section.

(b) These check test plates shall be used for tensile and bending tests as specified below.

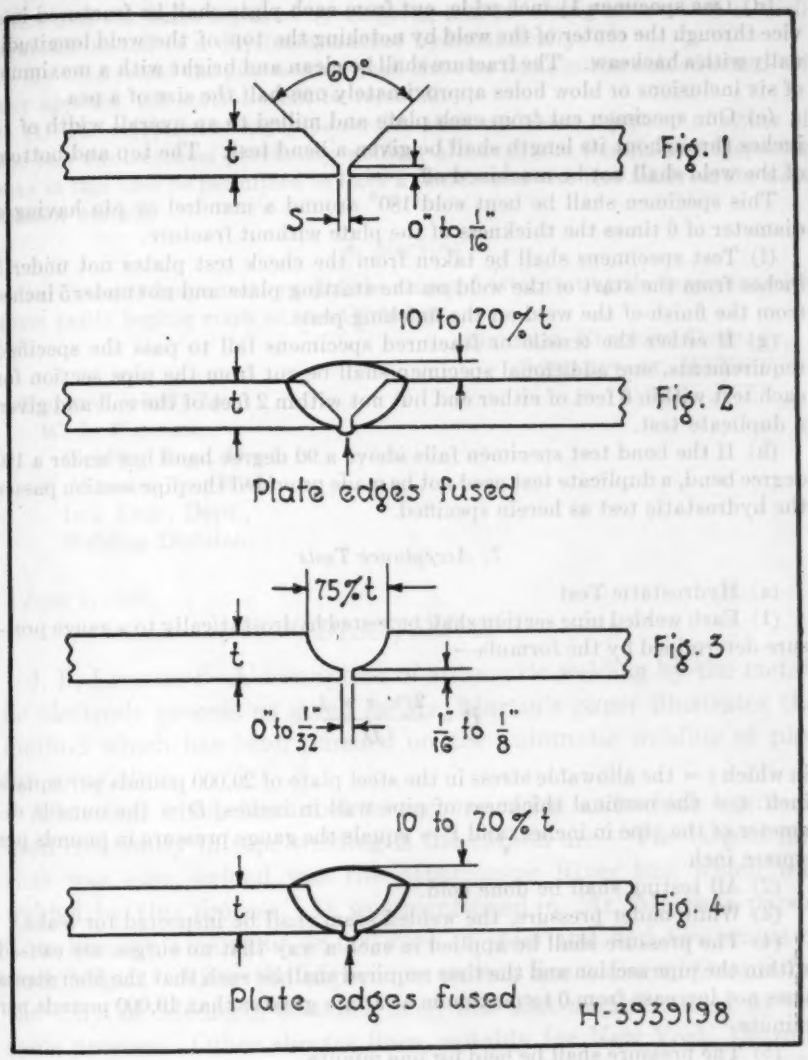

FIG. C. WELDS AND BEVELS FOR PLATES ¼-INCH THICKNESS AND ABOVE FOR 100 PER CENT STRENGTH JOINT

(c) One specimen 1½ inches wide, cut from each plate shall be given a tensile test. This specimen shall have a gage length of 8 inches machined to a width of 1 inch and shall be tested without machining either the top or bottom of the

weld. The ultimate tensile strength of this specimen shall not be less than the rated strength of the plate, or less than 50,000 pounds per square inch of plate section.

(d) One specimen 1½ inch wide, cut from each plate shall be fractured in a vice through the center of the weld by notching the top of the weld longitudinally with a hacksaw. The fracture shall be clean and bright with a maximum of six inclusions or blow holes approximately one-half the size of a pea.

(e) One specimen cut from each plate and milled to an overall width of 1½ inches throughout its length shall be given a bend test. The top and bottom of the weld shall not be machined off.

This specimen shall be bent cold 180° around a mandrel or pin having a diameter of 6 times the thickness of the plate without fracture.

(f) Test specimens shall be taken from the check test plates not under 5 inches from the start of the weld on the starting plate and not under 5 inches from the finish of the weld on the finishing plate.

(g) If either the tensile or fractured specimens fail to pass the specified requirements, one additional specimen shall be cut from the pipe section for each test within 6 feet of either end but not within 2 feet of the end and given a duplicate test.

(h) If the bend test specimen fails above a 90 degree bend but under a 180 degree bend, a duplicate test need not be made provided the pipe section passes the hydrostatic test as herein specified.

7. Acceptance Tests

(a) Hydrostatic Test.

(1) Each welded pipe section shall be tested hydrostatically to a gauge pressure determined by the formula—

$$P = \frac{2 \times s \times t}{D}$$

in which s = the allowable stress in the steel plate of 20,000 pounds per square inch: t = the nominal thickness of pipe wall in inches; D = the outside diameter of the pipe in inches; and P = equals the gauge pressure in pounds per square inch.

(2) All testing shall be done cold.

(3) While under pressure, the welded seam shall be inspected for leaks.

(4) The pressure shall be applied in such a way that no surges are caused within the pipe section and the time required shall be such that the fiber stress does not increase from 0 to maximum at a rate greater than 10,000 pounds per minute.

(5) The pressure shall be held for one minute.

(6) All leaks in the welded joint shall be marked plainly.

(7) The pipe section shall be considered as acceptable provided the number of leaks is below one for each 5 feet of welded seam and duplicate tensile and vise tests have not been required.

(b) Check Tests.

(1) If duplicate tensile and vise tests have been required, then the pipe

section shall be acceptable only if the number of leaks is not over one for each 10 feet of welded seam.

(2) In either case the pipe section shall be removed from the testing machine and the leaks repaired by chipping and rewelding after which it shall again be tested in a duplicate manner hydrostatically.

(3) On a retest the pipe section shall show no leaks in the welded seam. If any appears, the section shall be rejected.

(4) The rejection of any pipe section shall not cause rejection of either of the last two sections previously welded, although the Purchaser's inspector may in this case be permitted to have a tensile and vise test made on the next section welded.

8. Marking

(a) Accepted pipe sections shall be stamped after test by the inspector with some easily legible mark or identification.

GENERAL ELECTRIC COMPANY,
SCHENECTADY, N. Y.

Prepared jointly by:
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June 1, 1929.

DISCUSSION

J. F. LINCOLN:[3] A description of automatic welding by the metallic electrode process as given in Mr. Martin's paper illustrates the method which has been pursued on the automatic welding of pipe for some time.

A method which has much to recommend it and which has been used frequently in pipe welding is the carbon arc. The largest line that was ever welded was the Mokelumne River line which was welded by this process. It was mentioned in Mr. Martin's paper. This line contains some 78,000 tons of steel and had two seams in each length. After the experience on this line a line in Oregon for the City of Medford, 30 miles long, was also manufactured by the same process. Other shorter lines, notably for New York, Detroit, Denver, Portland, Oregon, and Tacoma, Washington, have been fabricated in the same way.

Lately, however, another process, called the Electronic Tornado process, has been developed. It has a number of advantages such as the elimination of bevelling, the elimination of electrode metal, the practical elimination of repairs, and greatly increased ductility

[3] President, Lincoln Electric Company, Cleveland, Ohio.

at slight cost. This process depends on the carbon electrode arc, but instead of its being the wild, easily ruptured arc which has been used heretofore, it includes a method of focusing the arc and reducing the size of the crater, so that the welding work can be done with very much greater speed, with greater penetration and with reliable results.

A method of introducing into the arc a fluxing material has also been found, so that the welding is done in a reducing atmosphere, thus eliminating the great bugbear to welding, that is, brittleness, the result of oxidation. The Electronic Tornado welds are entirely ductile and will bend almost as readily as the plate from which the weld is made.

In applying this process the tractor type welder is used, reducing materially the costs of necessary machinery and of preparation.

The first plant put in for the Springfield job mentioned by Mr. Martin, cost, according to the owners of the plant, in excess of $50,000 —later plants put in on the West Coast cost about $30,000 each. The Electronic Tornado process used with the tractor type of welder will have a total cost not exceeding $5000. It eliminates the necessity of the delay between welds in lining up the pipe in the machine and turning it over after the first weld has been made. The apparatus normally would be merely lined up on the seam and traversed through the pipe under its own power.

The commercial feasibility of the present known methods of pipe welding will be determined largely on the basis of cost. The items of cost which make up the total are labor of the operator, power for the arcs, electrode filling material, delay between welds and interest and depreciation on investment.

Other factors affect this cost to some extent, such as the cost of grooving compared with the cost of shearing or planing, the cost of preparation of the shell for putting it on the bed, which requires the grinding off of the first bead hand welded, but these items are only minor. The comparisons in costs of two methods of welding are shown below.

	FIGURES (IN CENTS)				INTEREST AND DEPRECIATION AT 20 PER CENT PER YEAR
	Labor per foot	Power per foot	Electrode filling material per foot	Delay between welds per foot	
Electronic Tornado	2	2	2½	½	$1,000
Automatic Metallic Electrode	2½	6.2	12½	1	$6,000

These comparisons are made from the data given in Mr. Martin's paper compared with the results actually obtained by manufacturers using the Electronic Tornado process at this time. Judging by the results actually obtained when the Springfield plant was about half way through and in another installation somewhat larger on the Pacific Coast, these figures should be reasonably accurate.

It is difficult to express in cost per foot the matter of depreciation, but since the other figures are so expressed an attempt to do so seems desirable.

If each process could be kept in operation 80 per cent of the time for one year of 300 days, 10 hours per day, the output of each machine would be as follows: Electronic Tornado, 72,000 feet on $\frac{1}{2}$-inch plate; Automatic Metallic Electrode process with the double arc, 67,200 feet.

On the above basis the depreciation per foot with the Electronic Tornado would be $1\frac{1}{3}$ cents, and with the automatic metallic electrode welding, 9 cents. The total cost, including all above, would be for Electronic Tornado, $8\frac{1}{3}$ cents per foot, automatic metallic electrode 31.2 cents.

These figures would be materially bettered in so far as depreciation is concerned by having a greater number of heads on the automatic metallic electrode machine. The depreciation by some such arrangement could be reduced by as much as one-third. The other costs, however, would be approximately as indicated. The same advantage could be obtained by additional Electronic Tornado equipment operated by one operator from a single source of supply. In either case the complication would more than compensate for the reduced cost of depreciation and probably would not be economically justified.

There is little doubt that pipe in general will be made in the methods outlined. It is impossible for any other process even to approach the costs shown by either process discussed. The remarkable work that A. O. Smith of Milwaukee has accomplished certainly means that the tube mill process of manufacture of pipe cannot long endure.

E. E. SHANOR:[4] Mr. Martin has very clearly set forth some of the advantages of electrically welded pipes for water works service and one of the methods of manufacturing. We would call attention to an additional advantage. The smooth surface of the pipe is of

[4] Vice-President, Penstock Construction Company, Sharon, Pa.

benefit where a dipped coating is used, and of still greater advantage if the pipe is to be wrapped with saturated burlaps or tar paper. The rivet heads, and the lock bar on lock bar pipe, interfere with proper application of the wrapping.

The present practice in the East on pipe for city water works service is to use circular riveted field seams regardless of the type of shop seams. There is no reason why these field seams could not be satisfactorily welded. A great deal of difficulty was encountered on the Mokelumne job where they attempted to weld field seams. It is my understanding from conversation with parties interested in that work that the difficulty could have been easily overcome, but at an excessive cost, and it was the endeavor to keep the cost down that caused the trouble.

If one were to undertake to weld circular field seams on a large diameter pipe, the difficulties to be overcome are the lining up of the pipe and holding alignment, temperature stresses due to hot days, hot sun and cool nights, and contraction stresses due to welding. The maintaining of proper welding conditions, inspection, difficulties in rounding up the pipe, and troubles with coating are also to be considered. These are not insuperable difficulties, but are factors in the economic situation, which have indicated that for the present it is better to use a riveted joint for field connection. The fact that there are no difficulties due to lap or lock bar in this circular seam makes it possible to secure uniformly tight riveted field seams. Tests on welded pipe lines with riveted circular field seams will show an unbelievably low leakage.

It does not seem worth while to discuss or comment upon the methods of fabrication and preparation of the pipe for welding. The practice in all shops is substantially as outlined by Mr. Martin.

The Mokelumne job in 1925 was the first big pipe job to be electrically welded. The engineers on this job were men of more than national reputation and their decision to accept a welded pipe meant a great deal. Our Company bid on this job using riveted construction, and the decision to use welded pipe came as a distinct shock. We returned home and started an investigation on welding, as a result of which we sold the first large welded pipe job to New York City. This proved so satisfactory that welded pipe is now considered on every new specification, and has general acceptance.

It was the endeavor of welding engineers five years ago to weld $\frac{1}{2}$-inch plate in one pass. This practice, it has been demonstrated,

gives a weld which is very brittle on account of the poor grain structure of the deposited metal. It does not have good bending quality because of poor fusion at the bottom of the weld.

It has now been recognized that a 100 per cent weld is more uniformly obtained if the weld is made from both sides of the plate. It is also recognized that a better grain structure is produced if the deposit is made in several beads rather than in one. Mr. Martin's paper clearly shows modern practice in this respect.

During the past three years welding has been studied from the metallurgical as much as from its electrical aspects, and the metallurgist has been able to make many improvements in welding and to indicate defects and their causes; so much so that it is hardly possible to keep up to date and progress in the welding art without the assistance of a metallurgist and a well equipped laboratory.

It has been shown that defective deposited metal is produced due to the absorption of oxygen and nitrogen by the deposited metal in passing through the arc. This has been overcome quite successfully by the use of covered electrodes. The General Electric Company have developed a method of arc welding with bare wire in which hydrogen gas is fed through the arc and in burning around the arc absorbs the oxygen from the air. What effect this has upon the nitrogen we are not prepared to state.

The Lincoln Electric Company, in their carbon arc welding, feed paper with some chemicals into the arc so that the gases of combustion protect the arc from the air. These are very decided improvements in the art of welding.

Our Company uses a special flux covered electrode for all welding, which covering we apply ourselves. This cover is a development by our laboratory and is not a commercial proposition. The data given by Mr. Martin as to voltages and currents are not applicable to covered electrodes. Much higher voltages and amperages are required which produce a greater heat in the weld. This greater heat forms a very large puddle. It has been found that gases are freed very readily from this larger body of molten metal and a sound weld is produced. The flux used should exclude the air from the arc, purify the deposited metal, and form a slag over the weld, which would retain the heat and cause the weld to cool more slowly, all of which is of great advantage and produces a superior quality of deposited metal. Metal so deposited can be forged, blacksmith welded, filed and machined. It will have a tensile strength of from

60,000 to 70,000 pounds per square inch and a yield point of from 45,000 to 55,000 pounds per square inch, and an elongation in two (2) inches of from 15 to 25 per cent. It will consist of very well defined grains of ferrite, practically free from blow holes, segregations, iron oxide inclusions, and nitrogen needles. It is our practice to make our weld on $\frac{1}{2}$-inch plate and lighter in two passes, one on the inside by hand and one from the outside with an automatic machine.

It has been contended by some that electrically welded pipe should be annealed. In our method of welding, and presumably that used by the General Electric Company and the Lincoln Electric Company, the first deposit is thoroughly annealed when the second deposit is made. It is possible from the inside of the pipe to follow the course of the electrode on the outside by the bright red spot which shows through on the inside. This heat anneals and refines the grain structure. Contraction stresses in longitudinal seams are relieved by changes in shape of the pipe. In order to have a perfectly round pipe after welding allowance must be made for the change in shape, when crimping the plates. There seems to be no necessity for annealing the pipe made of plates less than 1 inch thick with longitudinal seams only. Above that is open for discussion.

We like to anneal all vessels 1 inch thick or thicker when welded, and consider it essential if the thickness exceeds $1\frac{1}{2}$ inches. It may be of interest to mention that the Petroleum Iron Works Company, of which the Penstock Construction Company is a subsidiary, has welded vessels of thickness in excess of 4 inches, weighing in excess of 100 tons, tested to 1600 pounds per square inch, and have equipment for forming, handling, welding and annealing vessels of any thickness and size up to 12 feet diameter by 70 feet long.

Specifications must be drawn which call for good welding at all times. Determine the best that can be done and strive for that, then consider what variations would be permitted. Mr. Martin has this in mind in his specifications which he has drawn up.

You will note he specifies that the bend specimen shall be bent cold 180 degrees around a mandrel or pin having a diameter of six times the thickness of the plate without fracture. This is the criterion of a good weld. In a later paragraph he states if the bend specimen fails above a 90 degree bend but under a 180 degree bend, a duplicate test need not be made providing the pipe section passes the hydrostatic test because he considers this will be good enough. Without discussing whether this test is severe enough or not the idea of making a maximum and minimum requirement seems good.

In the specifications for the Mahoning Valley Sanitary District pipe, which we are installing, the bend test calls for a bend around a pin whose diameter is three times the thickness of the plate, 180 degrees, without a sign of fracture. This is a most severe test and a failure to pass this test would certainly not indicate that the weld would not be satisfactory for the purpose intended.

We are glad to note that Mr. Martin specifies test pieces to be taken from coupons attached to the pipe. The practice of cutting test specimens from the pipe itself, and then patching the pipe, does not seem to be good. If the welding method has been established, and test has been made to prove it, there is little to be gained by bend and pull tests. Buyers of welded pressure vessels and welded products of all kinds rely upon the hydrostatic test, making this as severe as possible after having satisfied themselves about the welding process and the integrity and honesty of the manufacturer doing the work, with such inspection as can be made during the welding. The hydrostatic test should stress the plate to not less than 16,000 pounds per square inch, and not over 20,000 pounds, and while under pressure the weld should be hammered. If the welding is good there should be few leaks under test. We have tested for days at a time without finding a leak.

As it may be of interest, I am attaching copy of specifications for the work which we are doing for the Mahoning Valley Sanitary District, Contract No. 14, Section 29.40 to Section 29.47 inclusive, covering "Electrically Welded Pipe:"

SPECIFICATIONS OF THE MAHONING VALLEY SANITARY DISTRICT, CONTRACT NO. 14, SECTION 29.40 TO SECTION 29.47 INCLUSIVE

Longitudinal joints may be made by an approved method of electric welding which had previously been successfully used for welding pipe of large diameter for work of magnitude equal to that of this contract. The proposed process of welding shall be demonstrated for the approval of the Engineer before fabrication of the pipe is undertaken, and shall subsequently be subjected to the rigorous methods of inspection and testing specified in the sections here following.

If, at any time during the progress of the work, the welding process fails to meet the specified requirements, the process shall thereupon be discontinued, the material at that time remaining to be installed shall be rejected, and the balance of the work shall be completed by the substitution of pipe with some other type of longitudinal joint which will meet the requirements of the general specifications.

Electric welds shall be made by butt-welding with metal deposited in at least two separate layers.

All surfaces to be welded shall be thoroughly freed from dust, scale and dirt before welding. The welding rod shall be of such quality as will insure thorough penetration and sound welds. Any welding rod that shows undesirable properties during welding shall be rejected.

There shall be no flat areas along the longitudinal seams, and the welds at the ends of the pipe shall be ground flush with the plate where the welded surfaces are in contact after assembly.

Test specimens of weld. The Contractor shall cut from the fabricated pipes, and shall test in the presence of the Engineer, specimens of welded joints in the numbers hereinafter specified.

Two specimens shall be cut at each sampling, one to be submitted to a tensile test, and the other to a bending test. Each specimen shall be not less than 14 inches in length, and shall be machined to width of 1 or 1½ inches as ordered. The test specimens shall be cut with the weld running transversely through the middle of the specimen, except where longitudinal tests of the weld are specifically ordered.

The test specimens shall be selected by the Engineer at will from any part of the joint of any pipe, and shall be cut in his presence.

The Contractor will be permitted to weld a patch on the outside of the pipe to cover the area from which the specimens are cut, except that where specimens have been cut from the end of a pipe, the entire end of the pipe shall be cut off neatly to the extent necessary.

Tensile tests. Test specimens of welded joints shall develop tensile strength in general of not less than 50,000 pounds per square inch, and in no case of less than 45,000 pounds per square inch and shall break outside the weld. The unit tensile strength shall be determined by dividing the breaking load by the cross sectional area of the plate adjacent to the weld.

Bending tests. Test specimens of the weld shall withstand the bending test without any evidence of fracture either in the weld or in the adjacent parent metal.

The bending test shall be made by holding the specimen at the weld and bending the plate cold on each side of the weld to angle of 90 degrees from original position so that the distance between the two sides of the specimen will at no point be more than three times the thickness of the plate; or, if preferred, the test may be made by bending the specimen cold around a pin of diameter equal to three times the thickness of the plate, with the weld at the center of the bend.

The direction of the bending of the specimen shall be either towards or away from the center of curvature of the plate, as directed by the Engineer.

Preliminary tests for approval of process. Four sets of test specimens shall be cut from the first three lengths of pipe fabricated, each set consisting of two specimens of which one shall be subjected to the tensile test and the other to the bending test.

If the average strength of the four specimens subjected to tensile test falls below 50,000 pounds per square inch, or if any one specimen shows less than 45,000 pounds per square inch tensile strength, or if any one of the other four specimens fails to pass the bending test satisfactorily, then the material shall be rejected, the process shall be abandoned, and another type of joint which

will meet the general requirements of these specifications shall be substituted without delay.

Subsequent tests of weld. Following the successful completion of the preliminary tests and the approval of the welding process, test specimens shall be cut and tested from the joints of not more than 10 per cent of the total number of pipes fabricated. A larger proportionate number of test specimens may be taken during the earlier stages of fabrication, as the judgment of the Engineer may require, provided that the total number does not exceed 10 per cent of the number of pipes contemplated in the contract.

The failure of a single test specimen under either tensile test or bending test shall result in the rejection of the pipe from which the specimen was taken. The Contractor shall then cut and test two further sets of specimens from a second and a third pipe selected by the Engineer from the group of which the first pipe was considered representative. If both of these sets of specimens meet the test requirement, the pipes from which they were cut and the remaining pipes in that group shall be accepted; if any one of these specimens fails to meet the test, all of the pipes of the group shall be rejected, or at the Contractor's option each shall be subjected to individual test.

If, at any stage in the process of fabrication, 20 per cent of the number of specimens subjected to tensile tests shall have developed strength of less than 50,000 pounds per square inch, or if the same percentage of specimens shall have failed to pass satisfactorily the bending test, or if the character of failure of any lesser percentage of specimens under either test is such as to indicate, in the opinion of the Engineer, a dangerous lack of uniformity in the quality of the welds, then the process shall be abandoned as provided in Section 29.40.

WM. FLANNERY:[5] In addition to 14,000 feet of 60-inch and 4000 feet of 48-inch now under construction, there are completed and in service in New York City more than 34,000 feet of 60-inch and 7700 feet of 30-inch steel pipe, on which the longitudinal seams have been made by welding. Shop work on the first of these lines, which was laid in the Borough of Brooklyn, was started in September, 1926. The pipe was fabricated from forge welding steel plate $\frac{1}{2}$-inch in thickness and conforming to the A. S. T. M. specification A-78–27 Grade B, having a minimum tensile strength of 50,000 pounds per square inch It was welded by hand, using a metal arc process and depositing the metal in three layers, two on the outside of the pipe and one on the inside, the former being placed in a V shaped groove. The first layer of metal deposited in the groove was cleaned and peened before the following one was placed. This process was necessarily slow, one operator being able to account for not more than $\frac{1}{2}$-inch of completed seam per minute.

[5] Mechanical Engineer, Bureau of Water Supply, Department of Water Supply, Gas and Electricity, New York, N. Y.

The department specifications at that time called for 90 per cent efficiency of the joint. The hand welded joint had little difficulty in meeting this requirement.

At the beginning of the work a large majority of the tensile specimens broke outside the weld and this proportion, through the growing skill of the welder, had increased toward the finish of the contract to a point where the welds could have satisfied our present requirement that they develop the full strength of the plate itself. So that it is probable that, apart from the influence of the development of machine welding in raising the requirements as to strength of the joint, the improvement in skill of handwelding might of itself have sufficed to this end.

Our experience with the bending specimens, however, indicated that the companion pieces selected from the welds could not in all cases be relied upon to meet the test, viz: to bend 180° around a 1½-inch pin without sign of fracture.

The establishment of some definite standard to determine the ability of the weld to withstand bending was considered of primary importance. The department was initiating a general policy of using steel pipe for all mains of diameters of 30-inch and larger and it was felt that to approve the use of welded longitudinal seams for these pipes, without being certain that the seam would hold in the event of the partial or total collapse of the main, would be indefensible. That a steel main might or could so collapse when drained, in the event that the external pressure of the backfill were added to the effect of the vacuum created in the pipe, was evident from at least two instances of record.

In subsequent studies made, with the assistance of one of the pipe manufacturers, of the behavior of many specimens under bending, it developed that the smallest diameter around which the specimen could be expected to bend without fracture was 2¼ inch. This dimension was therefore adopted in our later specifications and still remains in the present ones.

Our specifications call for machined test pieces taken from the pipe itself. These are 1 or 1½ inch in width not less than 14 inches long with the weld running crosswise in the center of the specimen. These pieces when tested in tension must break outside the weld.

The approval of the welding process depends upon the behavior of test pieces not exceeding four in number which are taken from the first three pipes fabricated for the contract.

During the progress of the contract further tensile test pieces are taken from not more than 10 per cent of the pipe fabricated to determine whether the pipe represented by the specimens will be accepted. Failure of 20 per cent of these specimens results in the discontinuance of the welding process.

For each tensile specimen there is machined a companion specimen which is subject to bending. The following is quoted from the specification clause relating to bending tests:

"The specimen to be submitted to a bending test shall be bent cold. The weld during this test shall be held in the center of the bend and the metal at each side shall be bent back 90° from its original position. After the bend is completed the two sides of the specimen shall be at no point more than two and one quarter inches apart.

"The Contractor may, if he desires, make this bending test 180° around a 2¼-inch pin, provided with a groove to accommodate the projecting portion of the weld.

"The direction of the bending of the specimen shall be either towards or away from the center of the pipe as directed by the Engineer.

"If, under the bending test, any evidence of fracture should be indicated either in the weld or the parent metal, the pipe from which the specimen was taken shall be rejected.

"If the Contractor so desires a second and third bending specimen may be taken from the remaining pipe represented by the original sample. If both the second and third specimens successfully meet the bending test, the remaining pipe represented by the first test will be considered as having passed the test, otherwise they will be rejected."

It should be mentioned here that the clauses referring to both tensile and bending tests have been subject to many changes made in an endeavor to hold them in conformity with the rapidly changing art. The wording has consequently not always been as clear as might be desired. It is expected that the revision which is now being made will, when adopted, be less liable to misinterpretation.

Considerable change has occurred in the art since the first welded line was laid and there has recently been completed in the Borough of Queens a 60-inch line of more than 21,000 feet in length on which, by means of a larger metallic electrode, higher currents, the protection of the arc by a specially prepared electrode coating, a change in the shape of the welding trough and a combination of hand and machine welding, the rate at which the welded seam may be completed was raised to 2 inches per minute. This included the placing of two layers of deposited metal on the inside and one on the outside of the pipe. In addition, it has been made possible to produce welds

regularly that will show 100 per cent efficiency of joint and meet, and even in some cases exceed, our bending test requirements.

Work is now under way on a 36-inch steel line about 3000 feet in length for the Borough of the Bronx. A carbon arc welding process is being used on this line, which carries one longitudinal welded seam. In this process the plates from which the pipe are made are planed square and butted together. Only a small amount of metal, furnished by a welding strip placed over the seam, is added to the joint in welding. The metal directly beneath the arc is protected from oxidation by the smoke of a paper strip which is fed to the arc from the carriage. Welds are placed on both the inside and the outside of the seam.

Specimen welds taken from pipe made by this process, by which one operator can complete almost 3 inches of welded seam per minute, placing one weld on the inside and one on the outside of the seam, have met our requirements both as to tensile strength and ability to withstand bending.

A modification of this method is now being used on the fabrication of 14000 feet of 60-inch and 4000 feet of 48-inch previously referred to on which shop work has recently been started.

The carriage on which the carbon electrode is mounted is fitted with small rubber tired wheels and travels along the seam, being guided by the operator. Both outside and inside of the seam are welded and the rate at which the seam is completed exceeds $3\frac{1}{2}$ inches per minute.

It might be of interest to add here, in concluding, that failure of tensile specimens in the weld under the present approved processes is comparatively rare. Very few welds have disclosed leaks under hydrostatic tests and these in all instances have been satisfactorily remade.

There is no record of failure of any of our welded pipe in service. Only one instance has occurred where the weld has developed a crack at the time the pipe were being assembled. This was due to the plate near the weld being deformed to an unusual extent in forcing the inner and outer sections of the pipe into position preparatory to riveting.

THE FIRST FLANGE WELDED PIPE LINE

By Lloyd T. Jones[1]

A year ago the author presented before the San Francisco meeting of the American Water Works Association a brief description of an entirely new development[2] in the girth welding of pipe lines. The results of pressure tests that were then shown indicated that beyond the possibility of doubt the joint would perform satisfactorily[3] as a unit in a pipe line.

The first installation of a flange welded pipe line has just been completed. At first sight there might seem to be no relation between the new type pipe line and the "Days of '49" except that both happened in California, but the relationship is intimate.

A large portion of the water shed from which Pardee dam of the East Bay Municipal Utility District will hoard water lies in the Mother Lode country. Much of the area has been washed and scraped to bed rock. In some places however that is only now being accomplished. Mounds of rock and bleakness alone now mark the sites where, during the gold rush, thousands of people dwelt. So dense was the population that in some places the claims were less than 10 feet square.

Those were the days when San Francisco had more murders than Chicago, when lodging house guests slept with their boots on, but it indicated a certain lack of refinement for a man to sleep with his hat on.

All is now changed. No, not all. M'liss and Miggles are gone but Tennessee's cabin, Red Dog, Poker Flat and Whiskey Slide still exist and there are many replicas of John Oakhurst, the professional gambler; at least there were a few weeks ago. Also there

[1] Consulting Physicist, Berkeley, Calif.

[2] Journal, October, 1928, pp. 449–462.

[3] The new girth weld possesses two great virtues: (1) it eliminates residual welding stress and is applicable to pipe lines of even the largest diameters, (2) it provides a semi-flexible joint to care for seasonal temperature stresses or accidental stresses that may be imposed on the pipe line.

are vestiges of the mining methods of those earlier days. With one of them this pipe line is concerned.

Since 1850 the meandering channel shown in figure 1 has been carrying water from the Mokelumne river to supply the needs of hydraulic mining operations that are still being carried on, figure 2. The Jackson Creek spillway at the upper end of the Mokelumne

FIG. 1

Oh, a wonderful stream is the River Time,
As it runs through the realm of tears,
With a faultless rhythm and a musical rhyme,
And a boundless sweep and a surge sublime,
As it blends with the Ocean of Years.
—TAYLOR.

reservoir eliminated some 500 feet of this historic waterway and necessitated the construction of a steel pipe line to bridge the gap thus left.

The partially completed line, figure 3, shows the 24-inch pipe carried on piers—at 30 foot intervals—nearly 10 feet above the ground. The pipe was fabricated in 30 foot lengths, with stiffening rings over the piers, and the welds placed between the piers. It was not necessary to make any provision for expansion other than that afforded by the flange welds. Let us agree then that these girth joints which relieve welding stress and expansion stresses and at the

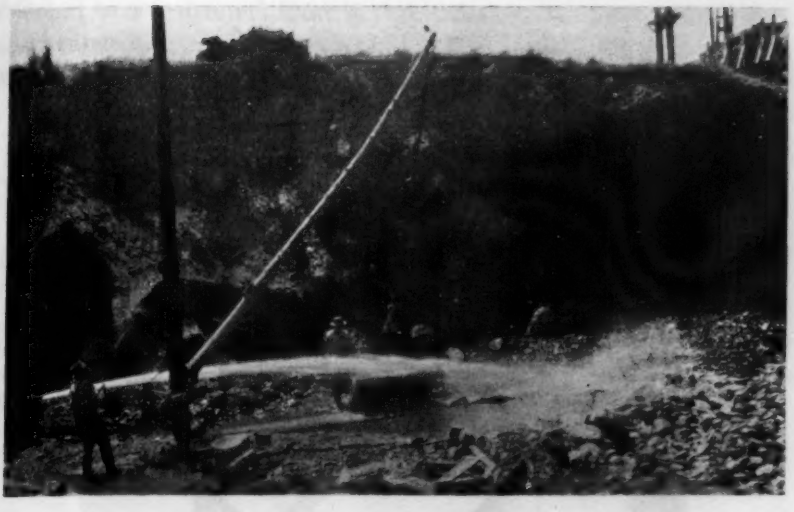

FIG. 2

This little old town was a placer camp
And the old fellows sure were keen;
They had worked the diggins time and again
And washed the bed rock clean.
—WEEKS, *The Ballad of Mokelumne Ed*

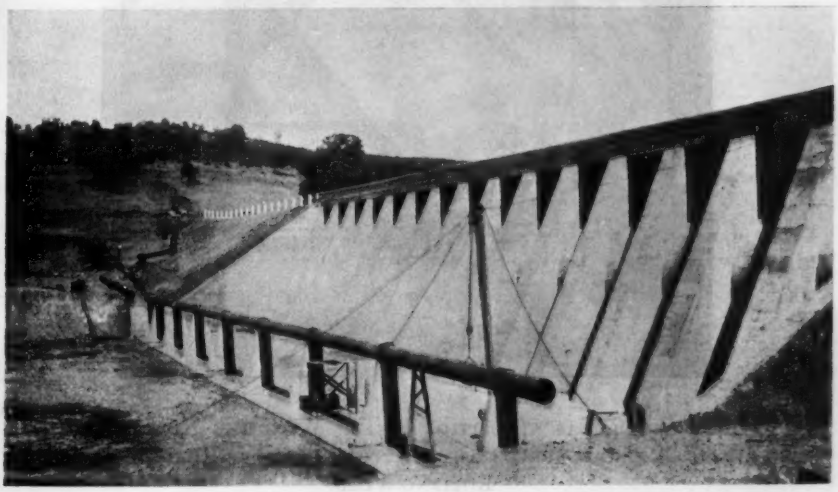

FIG. 3. THE JACKSON CREEK SPILLWAY OF THE MOKELUMNE PROJECT SHOWING THE 24-INCH FLANGE WELDED PIPE LINE PARTIALLY INSTALLED

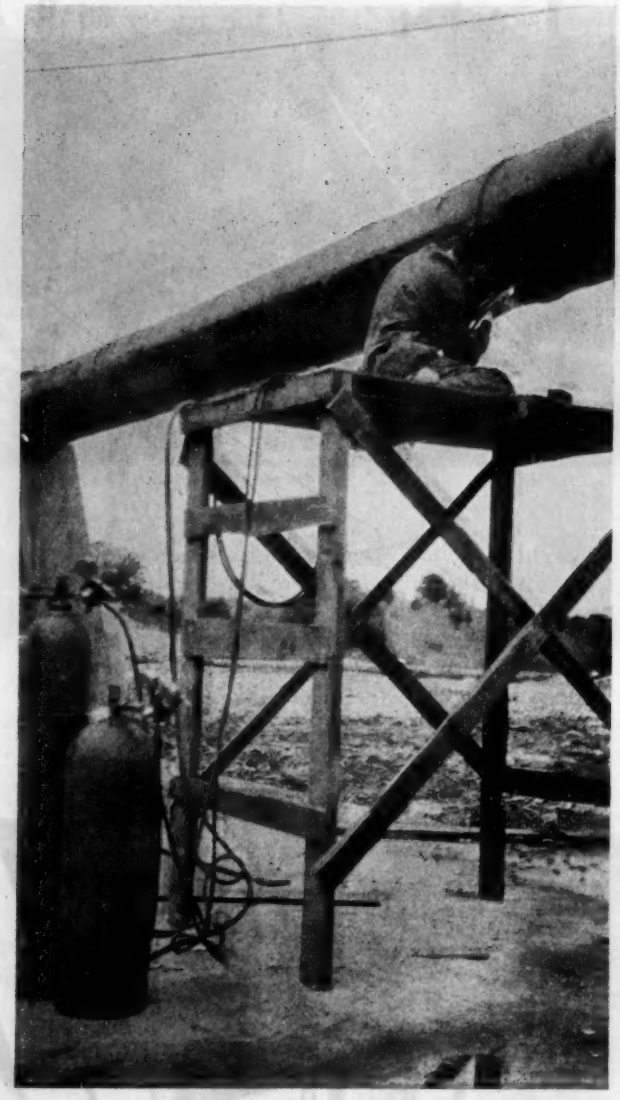

FIG. 4. EACH WELD WAS A POSITION WELD. WITH THE NEW TYPE GIRTH WELD A POSITION WELD CAN BE ACCOMPLISHED AS READILY AS A ROLLING WELD

same time carry the 3 tons of water in each pipe section are thereby subjected to a test much more severe than can be presented by any buried pipe line. As a matter of fact I believe I can demonstrate that the conditions under which this pipe line is operating are four

FIG. 5. A COMPLETED WELD

times as severe as would be imposed upon a similarly welded buried line.

Figure 4 shows Mr. Daniels at work on one of the inter-pier welds. I am indebted to Mr. Daniels for the excellent use of his skill in the performance of the welding.

Figure 5 shows a close-up of one of the girth welds. The flanges

were ½-inch wide, about four times the thickness of the steel of which the pipe was constructed. This width of flange is less than would be desirable for ease of alignment, ease of welding or best functioning in a buried line of the same metal. The lesser width was dictated by the strength of the pipe as a beam and the necessity of supporting the 3 tons of water in each pipe section.

In figure 6 the pipe line is shown complete and carrying water. Little need be said beyond the fact that it is operating under exceedingly severe conditions and performing perfectly satisfactorily the work it was designed to do.

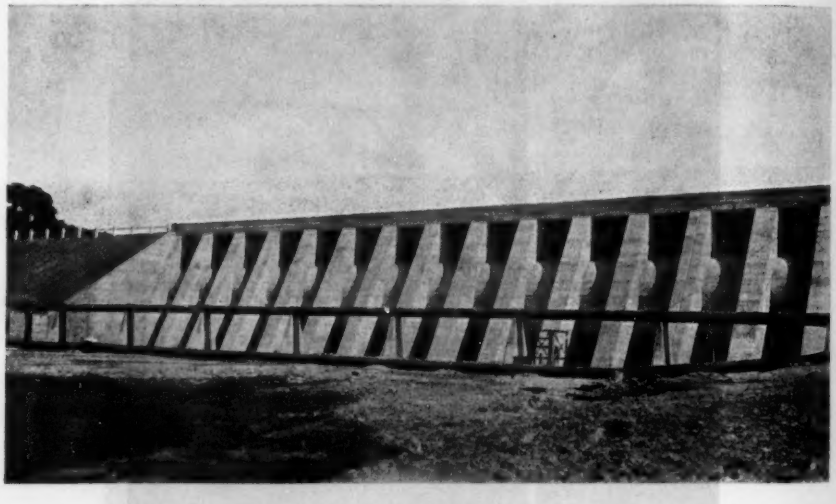

FIG. 6. THE LINE COMPLETE AND SUPPORTING NEARLY 30 TONS OF WATER

I am grateful to A. P. Davis and F. W. Hanna of the East Bay Municipal Utility District for their confidence in the results of the work I have accomplished in pipe line girth welding. My gratitude is also due G. H. Raitt of the Steel Tank and Pipe Company of California whose company made the complete installation and who bore the financial risk that besets pioneering projects.

The Victor Welding Equipment Company of San Francisco graciously extended the services of their Mr. Daniels and supplied equipment for my personal use in the welding. Without the coöperation of those mentioned this proof of the new girth weld could not have been made.

ENGINEERING PROBLEMS IN WATER RIGHTS[1]

By George M. Bull[2]

Engineering problems in connection with water rights in the semi-arid region, where agriculture is carried on by the application of water to supplement the rainfall, are quite different from the problems confronting the engineer in localities of abundant rainfall.

Where rainfall is abundant and the rights in water flowing in streams are governed by riparian laws, the usual physical condition that exists in reference to stream flow is, that to a certain extent floods are a menace to the property situated along the banks of flowing streams. In the main the problem is to pass the water almost undiminished in volume along the water channel in such a way that there is no damage to existing property or lives. The vast bulk of the stream flow has no local value to those adjacent thereto.

Where irrigation is practiced, water actually has value. The ideal condition is so to divert its flow from the running streams that it is all consumed by municipal and agricultural users. That is, water flowing in the stream in the semi-arid country is a prime necessity in the development of the region, while in humid countries it has little, if any such value.

In humid countries it is a comparatively simple matter to determine the status of the right to develop additional water for municipal purposes, in that the problem consists in the equitable distribution of available water by the communities that need to be served, together with regulation for navigation where required and settlement for damages done under the riparian laws to adjacent land owners or possible power developments. When this is done municipalities can delay actual development until the water is actually needed.

In the semi-arid region it is more difficult for all the water has at least a potential value for future use in irrigation and it will be ultimately consumed in agriculture. The laws of the various semi-arid states provide for the appropriation of the water for agricultural

[1] Presented before the Rocky Mountain Section meeting, February 15, 1929.

[2] Consulting Engineer, Board of Water Commissioners, Denver, Colo.

purposes when not beneficially used at any time when the need may become apparent. This usually leads to some time in which all the water is thus beneficially appropriated and used.

Before discussing briefly the problems of the engineer in connection with the securing of water rights for municipal purposes, it might be well to state briefly the actual situation that exists in the appropriation and diversion of our water supplies wherever irrigation is practiced.

It early became evident to those who settled in the semi-arid regions of the United States that it was necessary to supplement the ordinary rainfall with water artificially applied in irrigation, if agriculture was to be carried on with any degree of certainty or success. There were few, if any, legal guide posts governing how this should be done to safeguard the appropriators and the public in general, or to provide that the laws governing the appropriation would eventually lead to the final economic development and use of the entire supply available.

Fundamentally, there are three parties interested in the development of any water right: The appropriator who has a right to the use of the water appropriated, subject to his duties to other appropriators, that he so uses the water as to not infringe upon other users either by taking their water or by uneconomic use of his own; and also the duty that all the appropriators owe to the people at large, that the water be used efficiently so that there will be the greatest good accomplished, for fundamentally there was no object in granting water rights to individual appropriators except that such use was necessary for the public good. Under existing laws and uses the rights of the public as a whole, while they are of primary importance, are vague and undetermined.

When the laws were established for the appropriation of water, water was plentiful. Its use was not extensive and its value not great. As a natural consequence the laws were based upon fundamental principles, making it easy to appropriate water with little or no regard as to whether or not the method of appropriation safeguarded in any way the ultimate economic consumption of the water supply. Under the law, appropriators were entitled to developing water supply regardless of the geographical location on the stream under the system of *First in Time, First in Right*, and that is practically the system that exists to-day in Colorado.

The actual development of a stream such as the South Platte is

in general typical. Except such waters as were acquired for early placer mining and other mining ventures, the first appropriations were for comparatively small agricultural areas scattered along the Platte and its tributaries that furnished food stuffs for the various mining districts in the vicinity. These developments were later followed by community constructed systems of large acreage to meet the needs of the growing population. During this period of development there were no towns requiring water supplies of magnitude, except towns that sprung up almost overnight directly in the mining districts themselves. Water supplies for such towns as Ft. Collins were not required until after the agricultural areas were established and early water rights of magnitude developed for farming purposes. Denver's demand for water grew only as the city became a large center of population serving the state as a whole as its metropolis.

In other words, water supplies for towns and cities as a general thing have had their initial appropriations of comparatively junior date, their supply consisting of such junior appropriations augmented by the purchase of early irrigation rights and further augmented by the storage of unappropriated flood waters of an even more junior date.

The phenomena of stream flow of the South Platte are very typical of other rivers in the semi-arid region. There is a great variance in yearly supply from the normal over-long periods of years as reflected in the minimum and maximum years of flow. Years of great drought furnish only from 35 to 40 per cent of the normal and years of extreme runoff about 250 per cent of the normal. There is also a great variation in the normal runoff during the various months of the year. During the so-called irrigation period about 85 per cent of all the water supply available for the year occurs, and in the non-irrigation period, or winter period, about 15 per cent.

Appropriations for agricultural purposes commenced about 1860 and by 1880 practically all of the water entering the plains from the South Platte that came with sufficient regularity to be efficiently used directly without storage was appropriated. In round numbers this direct supply represented about two-thirds of the normal yearly flow of the stream, leaving about one-third available for development through the construction of reservoirs.

The earliest appropriations for the City of Denver for strictly municipal supply have the date of 1870. This illustrates the lag of time of appropriations for municipal purposes over the direct use for

agricultural purposes that were necessary before towns of any magnitude that depended upon economic growth of the country could come into being.

The City supply was supplemented by the purchase of some old direct irrigation rights, and to provide for the further growth of Denver Lake Cheesman was constructed to a capacity of some 79,000 acre feet, this being the first development of magnitude securing water from the flood flow of the upper river.

During the period of direct irrigation development something like 35,000 acres were irrigated directly from the river above Denver and about 90,000 acres below the City and above the Cache La Poudre. These are general figures. In the development of these irrigation rights something like 860 second feet of actual capacities were constructed above Denver and 3,400 second feet below Denver and above the Cache La Poudre for the purpose of irrigating the before mentioned acreages by direct irrigation. Normally this is a much greater capacity than the peak floods of the ordinary year's runoff.

The water is appropriated in nearly fifty ditches, having something over eighty appropriations. Following these developments by the City and agricultural interests for the direct use of water and the initiation of storage rights by the City in Lake Cheesman, new agricultural interests entered upon flood water developments for the purpose of irrigating large additional acreages by flood waters.

This paper is not intended as a description of the problems of water supply for the City of Denver, but as a typical illustration of what occurs in the sequence of development of the waters of a river subject to irrigation.

First, the agriculturist develops the country and makes possible the growth of towns and cities by creating an agricultural structure; second, this is followed by the growth of the local towns caring for the needs of the local agricultural communities, followed by the larger cities which are possible when the wealth of the community makes use of the service of larger towns with their greater industrial activity. Towns and cities must of necessity under ordinary conditions secure their supply for their growing needs from somewhat junior direct appropriations, the purchase of existing earlier agricultural rights, and the development of storage supply from flood waters, perhaps augmented under some conditions by the bringing of water to the City system from outside sources where conditions do not make it available for local appropriations and use.

The agriculturist ordinarily takes from the stream in his irrigation ditch about twice as much water as is actually consumed in evaporation and plant growth. The remainder is a common carrier supply that is used to convey water that is actually consumed to the lands irrigated, where it sinks beneath the zone of evaporation and eventually finds its way back ordinarily to the river from which it is diverted. This augmented stream flow is then subject to use by other appropriators in accordance with the priorities in ditches below.

The fact that there is no geographical factor taken into account in the principle of *First of Use, First of Right*, is one of the greatest drawbacks to the economic development of our water supplies, for it does not give weight to the great advantages of the use of return flood waters accruing on the upper reaches of streams furnishing water for irrigation. Some weight of priority right, because of the location of lands at the head of irrigation, would often result in as good or a better water supply for all those interested, and would make available efficient irrigation on the upper reaches of streams where very inferior agricultural developments now exist. This, however, is probably a somewhat academic consideration of facts under existing conditions of development.

DIFFERENCES IN USES OF WATER

A city or town uses and consumes its supply in a very different way than the irrigationist. In agriculture the appropriation is usually only utilized during the growing season. A city or town requires a daily supply through the year. Further, the volume actually consumed is quite different.

As an example during the last few years the City of Denver has measured the return flow of the water from the sewers in conjunction with the daily measurements of inflow of the City water supply. Each is recorded by time measuring devices. Those interested in a study of this nature are referred to a very able report on the result of these measurements by S. T. Weller, Civil Engineer of Denver, Colorado, in the Engineering News-Record of April 5, 1928. The data compiled show that the actual supply required by the City during the winter and non-irrigation period of lawns is only about 60 per cent of the total daily supply required during the summer when irrigation of lawns is required. During the period when there is no irrigation of lawns, the sewer measurements are about 95 per cent of the total water turned into the distributing system. The

hourly variation of supply and sewer flow shows that the inflow of other sources than the sewers is comparatively negligible. During the time when irrigation of lawns is extensive, only about 60 per cent of the water turned into the distributing system returns through the sewers. During the entire year something like 75 per cent of all the water diverted and turned into the distributing system returns to the river through the sewers, the annual loss in consumption for all municipal purposes, including lawn irrigation, being about 25 per cent.

There might be some question as to there being a material inflow to the sewers from outside sources, but then there is also some return from street washing, flushing of storm sewers and lawn irrigation, which enter the river through the storm sewers or by percolation and is not measured. These should at least offset any such inflow. This statement is made after a substantiation of the measurements of 1927 given in Mr. Weller's paper by those of 1928. This, it is believed, should be a fair statement in regard to the consumption of water by any town requiring excessive lawn irrigation having return sewers in which water wastes are carried to the stream.

This statement of municipal consumption refers to the treated water entering the distributing system. There are additional losses occurring in the raw water in storage and treatment that may run from 15 to 20 per cent, depending upon local conditions. It can be stated, however, in the main that outside of evaporation from reservoirs, such losses return to the stream in about the same way as irrigation returns. There are also additional losses that may occur in an irrigation system due to evaporation from reservoirs that have not been considered, so the conclusion may be reached that under certain conditions municipal consumption supply might be as much under unfavorable conditions as would occur in irrigation systems under favorable conditions, but ordinarily you would expect a greater total loss of consumption in irrigation than in domestic supply.

In general it can be stated that any municipality requiring a comparatively large water supply must secure it from one or more of four general sources:

First, comparatively junior direct water right appropriations;

Second, the purchase of senior irrigation rights that are so located that they can be transferred to the necessary points of diversion;

Third, the construction of storage reservoirs to control and utilize the flood flows not available for direct use;

Fourth, the development of supplies from sources outside of the natural drainage area furnishing the municipal supply that can be brought into the system as water not subject to local adverse appropriations.

APPROPRIATION AND DEVELOPMENT

The problem of appropriating and developing the direct water supply is comparatively simple. It consists in the engineering required for legal and construction purposes, and construction of such diversion works as will incorporate the supply into the municipal water system. Ordinarily actual operation of the water plant during the growing period of the early demand for water for the system will develop what this supply represents after senior appropriators have secured their supply and before there are large outlays in the purchase of senior irrigation rights and large sums spent in the development of storage reservoirs.

The purchase and transfer of old direct agricultural water rights to a point where they can be incorporated into the water system is usually difficult, unless it can be accomplished by a compromise and adjustment with adverse users. Assuming that the town requiring the transfer of water to municipal use is located some distance below the point where irrigation commences on the stream, there is always the question of how much of the actual water supply that it is desired to so transfer is actually called for on the senior appropriations at the point where the water system diverts it, whether or not it is not supplied by the return seepage from other sources, and whether or not the actual use is at all comparable with the amount of the appropriation, and to just what extent other users up and down the river above the sewer return of the city are injured. It is not ordinarily hard to show that the losses in irrigation above a city from the amount of water that might possibly be transferred would not be as great or greater than the losses in consumption for municipal purposes if the water was used directly as diverted. At least the possible additional loss caused by municipal use could be adjusted to satisfy any supposed losses to irrigationists below.

It is, however, extremely difficult where a stream is intensely appropriated to show that a transfer would not affect injuriously, at least to a considerable extent, all ditches or many of the ditches above the city where the additional water was carried around early appropriations above the sewer return. An assembly of all the

facts as to water uses in various ditches, return flow, and the various actual demands for water of all users at the point where the new diversion is sought, is necessary in order to reach a correct conclusion. The actual use and consumption of the supply that is sought to be transferred must be very definitely known. Many appropriations are greatly in excess of actual requirements and only a maximum of what has been used can be transferred. It can be glibly said "Why, a municipality can condemn water for domestic purposes." That is true, but when a municipality initiates condemnation proceedings to appropriate the waters used by John Smith, the condemnation proceedings do not stop there. If this water supply is taken, the proceedings must include the damages that may occur to any or all water rights in the drainage area. It has been the experience of the writer that where water is required for municipal purposes from any area under irrigation, the most satisfactory way to proceed is to cover not only the rights and requirements of the special right under consideration but to consider existing conditions throughout the whole agricultural area that may be effected, and then attempt to secure the supply by negotiation and compromise with all who may be interested, with such negotiation based upon facts that all know to be fair. Such investigation should not only bring out the matters involved in the procuring of additional water, but should clearly indicate the general effect on the agricultural situation of territories adjacent to the town or city securing the supply, in order that a proceeding for obtaining new water should be modified at least to the extent that surrounding territory is not damaged so that the result as a whole is detrimental to all concerned.

In securing additional water by the construction of reservoirs to control flood supply, ordinarily the needs for water for a municipality from storage should pre-date any large development for storage for irrigation purposes, and usually the municipal storage rights, if not senior, are at least developed at a time when considerable water is available for the development. When a water supply is being developed for municipal use, as is ordinarily the case, the city's direct rights must be supplemented by storage. Storage is required for two purposes: First, it must iron out the annual supply available from the development so that it adds materially to the supply under normal conditions. It has a second value, and fully as important a value, in that it must create a reserve to furnish water in periods of continued drought when water is not available from the normal

storage supply and direct supply. Under the most favorable conditions, the building up of a municipal water supply must proceed a number of years in advance of the time when it is to be all actually required in daily use. This is a great burden to the present water consumer.

The ideal condition of building sufficient storage capacity in reservoirs to complete the ultimate development of a water shed may be ideal, but it may be an ideal that leaves the community in bankruptcy. To construct a reservoir, however, at a time when its priority is sufficiently senior to developing a supply that normally will fill the reservoir each year and then maintain in that reservoir a reserve for periods of drought that make it only possible to utilize a comparatively small percentage of the capacity for the actual creation of water each year, eventually leads to a practical annulment of a large part of the use of the early priority. This can only be remedied by construction at some later date of additional capacity under a more junior appropriation where such storage reserve can be held. It, of course, follows that such additional storage should be made at the earliest time that it is financially practicable and to such an extent as the future needs of the municipality warrant.

As our country increases in population and in wealth, we are gradually approaching the time when further material progress that depends upon water as a necessary element will be greatly hindered and in many cases cease to take place, unless such water supply as locally exists is controlled and administered in more economic ways than arise from existing conditions of appropriation, or water can be obtained from other sources where it is not valuable or possible of local consumption. Such development of water supply for municipal use is to a certain extent a local problem, while those previously discussed are general.

Towns situated near the foothills of the Rockies have at least possibilities in augmenting the future supply in many instances in one or both of two ways. In many of the mountain parks the only agricultural use of water is in irrigation of native hay. Here the lands are flooded and there is a considerable actual consumption by evaporation and plant growth. Something like an acre foot of water per acre is consumed in such agriculture. The abandonment of irrigation would automatically increase the stream flow entering the plains by the elimination of this loss. There is little question that the water would have a greater economic value if used for

municipal purposes and irrigation purposes on the plains where higher grade crops are grown than as at present used.

There are some localities where it is possible to construct trans-mountain tunnels and diversion works on the western slope and thus divert new supplies from regions of so rugged a topography that there is little or no possibility of local use of the water so diverted. The development of such new supplies as here outlined have a much broader significance in the upbuilding of the community as a whole than the mere development of a municipal water supply. As stated previously, something like 75 per cent of the water utilized for city consumption eventually gets back to the stream. If this is water from an additional source it means that this supply could be available for agricultural uses for which water did not before exist, if this new water can be applied with reasonable limitations to new uses rather than be divided among older appropriations under existing early priorities. It is a simple matter to determine the amount of additional water that may be brought to a water shed from some other water shed for it is subject to a reasonable exact measurement. This is not true, however, of any additional water that might be secured from the suspension of irrigation on tracts of land within a drainage area itself, such, for instance, as areas of hay lands before mentioned. In practically all cases Park hay land irrigation is carried on under irrigation rights of comparatively junior priority. The amount of additional water flowing in the streams from the abandonment of such lands makes only a small additional flow when compared with the normal stream flow. Such water under present irrigation law and practice would practically all be automatically consumed by existing senior priorities. Such water could not be allocated to any special user without a determination by some properly organized fact-finding commission of the amount of the additional supply and an arrangement of the negotiations upon which it could be used.

A municipality that in its endeavor to secure large additional water supplies creates additional stream flow, some 75 per cent of which after the municipal use is an additional increment to the river, is performing a great public service in addition to caring for its own needs. It is entitled to the coöperation of every existing agricultural association that would be benefited. At least some of such water should be allocated to new uses that lend themselves to the economic development of the region as a whole.

The more one studies the problems of obtaining water for munici-

pal use, the more one realizes its inter-relationship to the final economic development of the water of the drainage system as a whole.

We cannot alone consider the necessities of water for the coming decade or even coming generation. We must look further and wisely plan that in the end both our agricultural areas and our towns and cities have utilized the supply to the greatest efficiency and economy.

We have reached the point in the development of our country where agricultural communities and municipalities must go hand in hand in an intelligent solution of these problems. Reservoirs will be eventually constructed in many places for the common good; appropriations will be adjusted to get the most benefit from seepage return. With due regard to vested rights, such things as may be done in the way of construction, legal and physical, will be accomplished.

The water works engineer must pioneer to this end. He must realize that the problems of the development and economic use of our water supplies is a problem common to all. He should coöperate with all interested in obtaining correct and impartial data for the upbuilding of the community in which he works insofar as water is an essential factor.

THE ETHICS OF ENGINEERING[1]

By Nicholas S. Hill, Jr.[2]

Unquestionably, one of the most gratifying changes which has taken place with respect to the engineering profession during the last century is the recognition of the fact that the engineer is not purely a technician, but that many engineers are endowed with broad common sense, judgment and executive ability. Whereas formerly men serving in public office, on national and state commissions, or selected as the executives of large corporations were drawn almost exclusively from the field of business and the legal profession, it is very common to see engineers selected at this date, and there is reason for this, for no training serves as well to fit a man for executive work, if he has innate executive ability, as the training of the engineer. The recent attempt, however, of engineers to push or promote the engineer for executive or public positions, just because he is an engineer, is in my judgment erroneous, because that is a matter of individuality. The engineer with the qualities and equipment necessary for an executive and with a leaning towards executive or public work will gradually emerge from the practice of engineering into executive fields, and will command the same respect and attention as a man of the same qualities and equipment who emerges from the profession of the law or medicine.

In saying this I do not wish to belittle the professional work of an engineer. On the contrary, there is a grave question in my mind whether the professional work of an engineer, although possibly it does not bring the same emoluments, is not equally as important and as meritorious as the work in the executive field. Notwithstanding this fact, the engineering profession must recognize that as the profession grows and this country is stabilized there is going to be a greater and greater demand for executive engineers, and the educators in our engineering schools should, in designing their courses, bear this fact well in mind.

[1] Presented before the Toronto Convention, June 26, 1929.

[2] Consulting Engineer, New York, N. Y.

ENGINEERS AS VOLUNTARY ADVISERS

It may be well in this connection to call attention to the pitfalls which await the engineer when he assumes the responsibility of a voluntary adviser in civic affairs.

When working by himself and entirely on his own initiative the engineer who takes up civic questions is likely to be cautious in his public utterances and to confine himself to fields in which his personal knowledge, experience and professional reputation qualify him to speak or write. On civic committees, however, the engineer is only too prone to go into fields outside of his own and presume to speak or write without authority. This is a mistake, and an injury to the profession, particularly in the event specialists are employed to advise with committees on which he may be a member. It is only in cities of considerable size, and not always then, that local engineers are available to deal authoritatively with highly specialized subjects. Whenever an engineer or engineering committee, not provided with funds to call in someone who is really expert on the subject in question, assumes the responsibility of giving advice there is always a danger of serious error, and there is also the danger resulting from the fact that the average citizen is apt to think that an engineer is an engineer no matter what the questions involved, and because an engineer or group of engineers in their midst is willing to supply information and advice gratuitously it is quite unnecessary to engage engineers and pay them for detailed engineering services. The engineer can do no greater service to his profession than frankly to admit his lack of knowledge on specific questions. He does not hurt himself by so doing for no engineer can be expert on all subjects. When an engineer serves on public committees which have to deal with technical questions he can perform no greater service than to advise his fellow citizens of the necessity of securing expert advice. The medical profession is far and away ahead of the engineering profession in this regard. The doctor does not hesitate to advise calling in a specialist and by so doing he does not feel that he is depreciating himself in the eyes of his patients. In fact, the very act of calling in expert assistance ennobles the profession. It leads the public to have confidence in the engineer and the engineering profession as a whole. The future development of engineering depends largely upon an appreciation of the responsibility of the individual engineer when he accepts service on public committees. It

is desirable that the engineer should be public spirited, but he may, unfortunately, do a great injustice to the profession unless he appreciates the necessity of expert advice.

UTILITY MANAGEMENT AND FINANCE

A great field of usefulness for engineers has developed with the growth of municipally owned utilities, particularly in the field of water works management and financing. The rapidly growing percentage of engineers on water works staffs is pleasing because it shows an increased recognition of the value of engineering in this field. The public water supplies of this country are in general municipally owned, but they have an enviable place among public utilities.

How are our public water supply systems to attain even higher standards than have been maintained in the past? The answer is: More efficiency in administration, finance and operation, as well as sound engineering design and construction. In saying this, the importance of sound engineering is not to be depreciated, for that is vital. What the water works of today needs most, however, is freedom from partisan politics and independent administration. Freedom from politics can be obtained by the education of the public and proper city charters which isolate the water department and treat it as a utility. The success of any business enterprise depends upon its conformity with the fundamental laws of political economy. The United States Supreme Court and other courts have held that when a municipality engages in the water business it conducts a commercial enterprise and is subject to the same rules at law as a private company engaged in the same business. The water department should, therefore, be maintained as a separate entity and be made responsible for the establishment of rates which will secure the revenue necessary, not only for its operation, but for financing new issues of securities necessary to meet the development of the service. All water revenues should be returned to the water department and applied by it to the needs of that department. In other words, the water works should be self-supporting. Water revenues should not be robbed for the benefit of other city departments and the water service thereby crippled. To rob the water department in this way is not only precarious, but is unjust to the water consumer who should not have his water bill increased to ease taxes for sewers, pavements, or other purposes. Engineers as a whole, I think,

recognize this principle, and the members of your Association can do a great public service by helping to educate the public to an appreciation of the necessity of treating municipally owned utilities as private utilities would be treated.

THE ENGINEER AND THE CONTRACTOR

The laws of most states and municipalities require that public contracts should be awarded to the lowest responsible bidder. This, no doubt, is the outgrowth of the lack of public faith in the public officials of the past. Everyone of you must recognize that serious trouble could be avoided and better work secured if municipal officials could call upon qualified contractors for special work, but, unfortunately, such discretion vested in official bodies has been abused in the past. Whether the abuse which would arise from allowing the municipal engineer to select qualified contractors for specific work outweighs the municipal losses sustained by the rule of awarding to the lowest responsible bidder is seriously to be doubted.

A great improvement in the integrity and honesty of municipal officials has developed in the last two decades, and everyone knows that the rule of awarding to the lowest bidder requires that the city officials be prepared to deal with the man who submits the lowest estimate for the work to be done, irrespective of his proficiency. As a result of this condition, it has been absolutely necessary that contracts be so drawn as to give the engineer the whip hand when he is forced to deal with unqualified or unscrupulous contractors. Many of the contract clauses which appear excessively harsh are a direct reaction from this method of letting work.

The engineering profession, by upholding a high ethical code in its membership, can re-establish the public confidence in city officials, and by so doing make it possible to deputize to the city officials the discretion necessary to secure competent contractors for public works. If this were done, many of the contract clauses which are now found in all municipal contracts could be toned down. Such a modification would not only be of benefit to the municipalities, but would be a decided advantage to responsible contractors.

I am a hearty believer that the engineering profession can accomplish a great work by giving the contractor a square deal, and anything that tends in that direction will be beneficial not only to the contractor but to the profession and to the clients represented by the profession. What I desire above all things to bring to your attention

is the failure of many engineers to give the contractor a square deal, to tell him fully and openly what they know of the conditions surrounding the work which he is to perform, as well as what they do not know, to the end that he may judge for himself concerning the risks and uncertainties of the proposed work.

I would also appeal to engineers to assume their own responsibility, to take the blame where they are to blame, and not to fall behind the broad but stringent clauses found in most public works contracts.

The reaction against these clauses is found in recent decisions of the courts. More and more the courts are finding that the mere writing of a clause in a contract does not make it binding, that a contract is based on equity, and that the contractor has rights as well as the owner. As a matter of fact, contractor and owner have a joint interest, namely, to do the work required as cheaply and as well as possible, and it profits no engineer to indulge in sharp practice upon the contractor. On the contrary, it profits him to help the contractor as much as possible. These principles have been recognized for years past, and yet how frequently we find the rulings of engineers on the interpretation of contracts and specifications overruled by the courts to the loss and detriment of the owner.

Such conditions not infrequently are the indirect result of competitive engineering bidding, and constitutes one of the evils which follow in the wake of this practice. Engineers who fail to ask for the compensation necessary to enable them thoroughly to make preliminary investigations and prepare plans and specifications based on accurate data not only hurt the profession, but do an injustice to the contractor who bids on incomplete plans and specifications, and as a result thereof exposes his client to loss. May I ask this Association to help in this regard?

ENGINEERING ETHICS

It is pertinent to ask whether the ethics of our profession has developed to the same extent as has the practice of engineering in the last century. I do not know how you feel about it, but it appears to me that unless engineers unite and insist upon high ethical standards in the practice of their profession, it is doomed to ultimate commercialism.

It is perfectly true that as this country develops it becomes increasingly difficult, nay, well nigh impossible, for the engineer to

develop a private practice by hanging out a shingle and awaiting the advent of clients seeking his services. On the other hand, there is no reason why the approach of the engineer seeking new engagements should not be professional, dignified and reserved, and there is no reason why he should in any way lower the standards of his profession or do injury to a brother engineer in so doing.

A custom much to be condemned and which, if not corrected, will certainly react detrimentally to the profession is to be noted. I refer to competitive bidding.

Nearly all of the professions recognize that it is unethical to compete with a fellow member for employment on the basis of professional charges by reducing his usual charges and attempting to underbid his competitors. Yet this is growing to be quite common among engineers.

Recently the city of Saratoga invited competitive bids for engineering and it was surprising to see that a number of engineers responded. A year or two ago Los Angeles felt called upon to advertize for outside engineering work and to award it to the lowest bidder. Even the Port of New York Authority some time ago extended an invitation for proposals to carry out certain important bridge designs. It called for bids on price and time of delivery of expert engineering services, services involving a very high type of specialized engineering skill and trained judgment, in precisely the same way that one would ask for price and time of delivery on coal or brick. This, so far as I know, is the first time a responsible and well informed public authority has resorted to the bidding system of selecting a professional man to direct the expenditure of large sums of public money.

This is bad professional practice, the evils of which are sufficiently self-evident to require no argument or proof. It is difficult to see any justification for it, and engineers who have regard for their profession certainly should not help such practices by submitting bids for engineering services.

I am sure that the men of the old school of our profession would have scorned such a proposition, and I think it is up to associations like yours to combat the tendency by making it apparent that members who participate in such practices are not welcome to the profession.

It may not be amiss at this point for our own edification to dwell for a moment upon some of the older men of our craft with whom as youths we were associated, and to recall the dignified poise of their

bearing, the outward sign of an inward consciousness of right doing which resulted from long years of sacrifice to their calling, to remember their rugged simple characters, their allegiance to accuracy and truth, and devotion to duty growing out of a love of their profession and the lack of desire for personal gain, and ask if the profession of today is actuated by the same high motives. I leave you to make answer.

ENGINEERING FEES

We find much complaint among engineers of the small remuneration which they receive. How can the engineer expect consideration from the public and a proper appreciation of his services when he depreciates his own services by failure to uphold the ethics of his craft? Conceive, if you will, of a body of lawyers submitting competitive bids for legal services, or a group of doctors bidding for the cure of a case of illness or for performing an operation. No one would dare approach a lawyer or a doctor on any such basis, and there is no more reason why the engineer should be approached in this way than the doctor or lawyer, and it will not be until the engineer has a full sense of his professional dignity and of the value of ethics in his profession that it will be recognized and respected as other professions are.

MISSOURI RIVER AND TURKEY CREEK PRESSURE TUNNELS[1]

By Charles S. Foreman[2]

Pressure tunnels for the transmission of large water supplies are generally conceded by engineers to be the most practical, economical and dependable method of construction in all cases where the character of the substructure is such as to furnish a suitable rock for tunneling methods.

Underlying the entire Kansas City area is a bed of hard blue shale interspersed with thin layers of limestone and sandstone. Generally speaking, this shale bed is approximately 100 feet below the surface, throughout the river valley.

In the design of Kansas City's new water plant, Fuller and Maitland, Engineers, decided upon pressure type tunnels for the transmission of water supply from the new plant in North Kansas City to the East Bottoms and Turkey Creek Pumping Stations. At a later date it was decided to substitute 54-inch steel pipe in place of the branch tunnel extending to the East Bottoms Station.

In April, 1925, contracts were awarded to Smith Brothers, Inc., General Contractors, for the construction of the Missouri Valley and the Turkey Creek Tunnels and actual construction work was started about May 15, 1925.

GENERAL DESCRIPTION

The Missouri Valley Tunnel is approximately 285 feet below the general surface of the valley and is approximately 15,500 feet long. The downtake shaft is located approximately 500 feet south of the Secondary Pumping Station in North Kansas City and is circular, 10 feet in diameter, with concrete lining. The uptake shaft is located on the south bank of the Missouri River, adjacent to and on the down stream side of the Burlington Bridge. It, also, is circular, 10 feet diameter, with concrete lining. The entire tunnel was driven

[1] Presented before the Missouri Valley Section meeting, October 5, 1928.

[2] General Superintendent, Smith Bros., Inc., Contractors, Kansas City, Mo.

from these two shafts and is of circular section, 7½ feet in diameter, the bore being 9 feet 4 inches in diameter.

The Turkey Creek tunnel starts from the south bank of the Missouri River, adjacent to the uptake shaft of the Missouri Valley tunnel and extends to Turkey Creek reservoir. It is approximately 11,500 feet in length of circular section, 6 feet in diameter, the bore being approximately 7 feet 4 inches in diameter. The downtake and uptake shafts are approximately 145 feet in depth on this tunnel. There was a construction shaft located at 12th and Santa Fe Street midway between the downtake and uptake shafts. This shaft was used only for construction purposes and to facilitate the rapid construction of the Turkey Creek tunnel.

CONTRACTORS PLANT

Four practically identical plants were operated at the five different shafts, all by electricity.

The plant at the uptake shaft of the Missouri Valley tunnel was of size sufficient to permit its use in the construction of the downtake shaft and heading of the Turkey Creek tunnel.

Current at 13,000 volts was stepped down to 220 volts, and all equipment above ground was motor driven. Westinghouse and General Electric Equipment, 60-h.p. electric driven, single drum hoists, operated the cages at rope speed of 350 feet per minute. Motor driven Gardner, 550-foot air compressors were installed at each of these plants. At the Turkey Creek downtake shaft and the 12th and Santa Fe construction shaft, ventilation was obtained from No. 3 Roots blowers, the air being conducted into the shafts and tunnel through 12-inch galvanized iron pipe. These blowers were capable of handling 3000 cubic feet of air per minute.

Ventilation in the Missouri Valley tunnel was obtained by the use of No. 5 Roots blowers driven by 125 horse power variable speed motors, the air being conducted into the shafts and tunnel through 14-inch galvanized pipe. These systems were capable of delivering 4500 cubic feet of free air per minute.

All materials were delivered to the downtake and uptake shafts of the Missouri Valley tunnel and the downtake and uptake shafts of the Turkey Creek tunnel by rail and to the construction shaft at 12th and Santa Fe by motor truck. Overhead bins and central mixing plants with one-half yard Ransome mixers were used for the mixing of concrete at all plants. Jeffrey elevator bucket conveyors

placed the sand and stone in the bins above the concrete mixers. This method of handling the materials proved very economical and satisfactory throughout the entire operation.

Elevated platforms and muck bins were used at all shafts for receiving muck. The muck coming from the Missouri Valley downtake shaft, or shaft No. 1, was wasted upon the site of the new water plant, being hauled by trucks from the overhead bin. The muck coming from the uptake shaft, Missouri Valley tunnel, or Shaft No. 2, and that coming from the downtake shaft of the Turkey Creek Tunnel, Shaft No. 3, was loaded into cars for shipment by rail, it all being disposed of by the Missouri Pacific Railroad Company in yard fills in the Centropolis District. The muck coming from the construction shaft and headings was disposed of by motor truck and that coming from the uptake shaft of the Turkey Creek tunnel, Shaft No. 5, was used to fill the abandoned bed of Turkey Creek.

CONSTRUCTION METHODS

The methods used in sinking the different shafts varied with the sub-surface conditions. Open shaft blasting and excavating, open caissons and pneumatic caissons, were found necessary on different parts of the work.

At Shaft No. 1, a concrete pneumatic caisson was used to sink the first 117 feet of shaft. The material penetrated was water bearing sand and gravel, resting on shale ledge onto which the caisson was sealed. This caisson was 10 feet inside diameter, 15 feet outside diameter, of concrete and steel construction. The caisson was constructed by use of the head house built over the shaft. A steel cutting edge was set approximately 10 feet below the surface of the ground and upon this, 45 feet of caisson was built. Air chamber and man tubes were placed in this section. After proper curing of the concrete, this 45 foot section was sunk in the usual caisson manner by blowing the sand and gravel, after which additional sections were built as required. After this caisson was sunk approximately 85 feet, considerable difficulty was experienced with the caisson sliding out of line and, regardless of all known methods which were used, it was impossible to land the caisson on the rock in perfect vertical position. However, it was sunk into the shale ledge approximately 3½ feet and sealed in by high pressure grouting. It was necessary, during the latter part of this operation, to maintain air pressures of 50 to 52 pounds and the contractor experienced considerable diffi-

culty in securing men who could work under these high pressures. After sealing in this caisson, the shaft was sunk as an open shaft with the usual drilling and blasting methods.

Shaft No. 2 was sunk from the surface of the ground as an open shaft. Shale, sandstone and limestone were encountered with a majority of shale. This material, after being exposed to the air for a short time, disintegrated very rapidly. Therefore, it was necessary to place the concrete lining closely behind shaft excavation. The contractor required all of his men working in the shafts to wear steel helmets such as the American soldiers wore in France.

Shaft No. 3 was also sunk in the usual open manner.

Progress of approximately $3\frac{1}{2}$ to 4 feet per shift of eight hours was made in the sinking of the open shafts.

The construction shaft at 12th and Santa Fe was sunk in a similar manner to Shaft No. 1, being sunk as a caisson for approximately 80 feet and requiring the use of air up to about 30 pounds pressure.

Shaft No. 5 was sunk as a caisson for approximately 45 feet, but did not require the use of air.

All drilling was done with light jackhammers, unmounted. Drills were all of the rose bit, 6 point type. Steels were $1\frac{3}{8}$-inch bit, decreasing $\frac{1}{8}$-inch in diameter for each 2 feet of length.

It was possible to sink the shafts in shale for some 30 to 50 feet before the sloughing of the shale made concreting necessary. The shafts were shot 6 to 8 inches inside of the final line with the idea that the sloughing would bring the shaft to section. This did not prove successful as the shale broke unevenly. A method which did prove successful, however, was the use of heavy pneumatic paving breakers and stoping machines for trimming to section. This method was also found the most satisfactory in trimming the tunnels to section.

In sinking No. 1 shaft it was necessary to load the caisson with 100 tons of steel rails, together with approximately 300 tons of sand.

No unusual methods of construction and very little difficulty was encountered in driving the four headings of the Turkey Creek tunnel, one heading being driven from each the downtake and uptake shafts and two headings being driven from the construction shaft. The entire tunnel was driven through hard gray shale requiring very little timbering. No water, but considerable oil was encountered.

It was found, in driving these headings, that the best progress could be made by drilling and firing two short rounds to each shift rather than the practice of one long round per shift. A round of shots

consisted of from 17 to 19 holes. These were loaded with approximately 38 pounds of 40 per cent gelatine dynamite, ordinary fuse and caps being used for detonation. Holes were drilled approximately 5 to 6 feet deep and the usual pull for each shot was from 4½ to 5 feet. Drilling operations were carried on at the same time as mucking, and progress of 8 to 9 feet per 8-hour shift was maintained practically throughout the entire work. The record driving was 221 feet in 21 consecutive 8-hour shifts.

Segmental steel forms placed upon angle iron rings were used for forming the lining. Concrete was placed by hand, being mixed at the shaft and delivered in small scoop cars to the forms. All concrete was 1–2–4 mix with Celite as an admixture. Water was controlled by measuring tanks and slump test.

Lighting was by electricity at 220 volts and haulage by mules. No gas was encountered in the driving of this tunnel and the ventilation provided was adequate at all times.

In driving headings from No. 1 and No. 2 shafts, Missouri Valley tunnel, practically the same methods were uses as described above in the drilling and mucking operations, except that electric detonaters were used for firing all shots.

In both tunnels an enlarged section of the same diameter as the adjacent shaft and approximately 50 feet long was built. The Engineers included this enlargement in the plans as an aid to the contractor and the same was used for the location of sidings on the industrial railroad. The transition to tunnel section was made in 10 foot lengths in the small tunnel and in 12 foot lengths in the large tunnel.

The first thousand feet of the Missouri Valley tunnel driven from Shaft No. 2 was through sandstone which did not require timbering or immediate lining. Practically all of the remainder of the tunnel was driven through shale and required heavy timbering. Water, oil and a considerable amount of gas were encountered throughout the entire operation. Many explosions and fires occurred, one in which an entire crew of eight men lost their lives and two others in which entire crews were very severely burned. The handling of this gas required very unusual ventilation and many special construction methods.

The general practice of driving headings in shale section in this tunnel was to fire two 6 foot rounds on each of the night shifts, having the timber gang come in on the 7 o'clock shift in the morning.

Mucking and timbering were carried on simultaneously during the first half of the day shift. This enabled the timber gang to timber up all exposed roof of the preceding two shifts. One round was fired in the afternoon of the day shift. An average progress of approximately 22½ feet per 24 hours was made in timbered section with this method.

The contract required the contractor to light the tunnel with electricity at 220 volts with approximately 40-watt lights at 50-foot intervals and also required all equipment in the tunnel to be operated electrically. After encountering gas in such large quantities it was necessary to modify this section of the contract and all electrical equipment was removed. Lighting was obtained by each man wearing a Super Wheat cap light and battery on a belt. This is a type of permissible lamp approved by the United States Bureau of Mines for gaseous work. All pumping was done by air driven pumps and all power machines used in the tunnel were driven by air. Haulage was by four ton General Electric storage battery locomotives of a closed permissible type.

The shale through which this tunnel was driven was of a nature which disintegrated and fell very rapidly after exposure to the air. The timbering used was the three segment arch method, lagging over the top of the timber with 2 by 12 yellow pine and using 6 by 6 yellow pine for arch blocks and legs. The shale was such that it could not be exposed to the air for more than 16 hours without very material falls. The legs supporting the arch blocks were set into hitches cut into the sides slightly above the spring line of the arch. It was necesary to use considerable dry packing above the timber.

Concreting was carried on in this tunnel in a similar manner to that described as used in the Turkey Creek tunnel, all being done by hand with the exception of a few sections which were placed by pneumatic concrete placers. While this method proved successful, it was not economical in comparison with hand placing as the small cross section of the concrete required the frequent moving of the placing machine.

VENTILATION

The most difficult problem presented was that of handling the enormous quantities of methane gas coming into the tunnel. The ventilating blowers, fortunately, had been provided of sufficient size to handle this gas. In the original installation which had been intended to furnish approximately 1500 cubic feet of air per minute

to the working face, this being adequate to take care of all requirements of men working in the tunnel, the blowers being so arranged with variable speed motors that after blasting, the direction of current could be reversed and the blower brought up to a full speed to be removing approximately 4500 cubic feet of air per minute from the face. It was originally intended to deliver the pure air to the face and after firing, extract the smoke and gas from the face by suction. However, after encountering the gas it was necessary to run these blowers at full speed at all times and the direction of the current of the air was down the shaft, through the heading to the face, and out through ventilating lines. This method kept the incoming gas more or less confined to the face and in most cases sufficiently diffused so that it was not noticeable or dangerous to the men. However, with this operation it was necessary to keep the ventilating pipe up close to the headings and when ready for blasting operation, it was necessary to remove approximately 80 to 90 feet of the pipe. After loading of the drilled holes by the crew and when everything was in readiness for firing a shot, the entire crew would remove this section of pipe and carry it back through the tunnel. They would then proceed approximately 1000 to 1200 feet from the face from which point the firing would be done by electric current.

In the first part of the operation, it was found that in the time required to take down the pipe and for the men to reach a point of safety the gas accumulated in the 50 or 60 feet adjacent to the heading in such quantities that when the shot was fired, there was a terrific explosion of gas, or the gas became ignited, causing a fire at the heading. Practically all of the gas was encountered at the heading and as the drilling was being done, the drills went into gas pockets which immediately began to blow into the heading. It was found necessary, for the protection of the men, to construct concrete shooting boxes outside of the lining of the tunnel. These were approximately 18 feet long, equipped with permissible closed telephones and firing circuit with firing switch of the oil enclosed type.

Each foreman of a crew was equipped with a Wolf Safety lamp for testing for gas and they were required to test the entire length of the tunnel at the beginning of each shift and at frequent intervals during the shift.

One of the difficult problems encountered was to find a dynamite of fast enough flame so as not to ignite the gas encountered at the face. Many permissible dynamites were used which did not ignite the gas.

However, the majority would not break the ground properly. After experimenting for a considerable length of time with some seven or eight different kinds of permissible dynamites we finally adopted the use of Gelobel, manufactured by the DuPont Company, which is a permissible dynamite approved by the United States Bureau of Mines for gaseous use and of a strength of about 40 per cent gelatine dynamite. It has a very fast flame and we had no ignitions of gas when using Gelobel.

Another difficult problem in connection with this work was to compel the various men employed to observe all of the rules and to make the necessary tests for gas, etc., for their own protection. Most of the men employed on this particular work are either coal miners or jack miners from the Pittsburg and Joplin districts, all of them of a more or less reckless nature. It required the constant supervision of safety men at all times.

A method which proved very satisfactory in helping to remove the gas was that of connecting $1\frac{1}{2}$-inch pipes from the main ventilating lines into gas feeders where encountered. This method of sucking the gas directly into the ventilating pipe before allowing it to enter the tunnel was very satisfactory for all portions of the tunnel except the immediate face.

The Turkey Creek tunnel was entirely completed by March 1, 1927, and was put in service by the making of a by-pass connection, May 1, 1927.

The Missouri Valley tunnel was holed through on October 28th, 1927, and all concrete lining, together with connections, valve pits, etc., were completed by April 15, 1928. The tunnel was then filled with water and tested at approximately 26 pounds per square inch. The test was conducted over a period of four days and at the conclusion of the test there was practically no leakage.

The tunnels have been in satisfactory operation since completion. The entire cost of this contract amounted to two and a quarter million dollars. All engineering, inspection, etc., was under the supervision of K. K. King, representing Fuller and Maitland, the engineers, and the writer was general superintendent for the contractor.

UNDERGROUND WATER RESOURCES IN THE VICINITY OF TACOMA[1]

By Homer O. Blair[2]

The area of the State of Washington that is covered by this paper is a section bordering on Puget Sound including the City of Tacoma and the country to the east and south comprising Pierce County, with a portion of King, Thurston and Lewis Counties. It includes about two thousand square miles of land starting from sea level and gradually rising by a series of plains, plateaus and foothills, to the snow-capped Cascades in the eastern extremity.

The northern and northeast extremity are drained by the White River. The Puyallup River and its main tributaries, the Carbon and the former Stuck River, drain most of the eastern and north-central parts, and the Nisqually drains the southern and extreme southeastern sections. The Puyallup Valley is one of the richest agricultural valleys in the Northwest and the lower part is a main thoroughfare between Tacoma and Seattle and is also followed by the steam railroads.

Most of the area south of Tacoma is occupied by expansive stretches of level and slightly rolling gravelly prairies, well drained, and thinly wooded and dotted with numerous lakes. The higher ridges are covered with timber and as we approach the east and south the timbered foothills soon reach the rougher mountainous region.

The city of Tacoma has a population of about 125,000 people and as it is the manufacturing center of this part of the state it requires great quantities of pure water from supplies that are reliable and do not fail during the dry summer months.

A full list of the things manufactured in the district would be very large, but a few of the products include lumber and various things included in the large related lines such as doors, veneers, furniture and shingles; pulp and paper, powder, meat products,

[1] Presented before the Pacific Northwest Section meeting, November 16. 1928.

[2] Consulting Engineer, Tacoma, Wash.

smelting, flour and car wheels. Tacoma has a larger percentage of population engaged in manufacturing than any city in the west.

PRECIPITATION

The high rainfall of this district is due to the evaporation of the Pacific Ocean and the moisture is carried to the mountains by the westerly winds.

The climate has not always been as at the present, since in our coal fields we find material of a tropical nature, while the flat plains and rolling hills of the prairie country to the south of Tacoma as well as the city itself are formed by great quantities of sand and gravel that were dropped by the great rush of waters during the centuries of the visit of the great ice glacier and its retreat to the north. Some of the formations might have been caused by the re-advance of the glacier and this period would have covered thousands of years.

The heavy precipitation of some portions of the section is due, of course, to the mountains, but were its whole surface uniform and of low level western Washington would still be well watered in the winter, or "wet season," for it extends across the highway of atmospheric vortices, or low pressure storms, that move from the North Pacific Ocean into the interior of the continent. The Olympic coast range in Western Washington forces the vapor-laden atmosphere coming from the ocean into the higher elevations, producing an excessive precipitation in the coastal counties, and again, the Cascades, lying in the prevailing course of the currents, reproduce the same effect over their western slopes and foothills.

The heavy rainfall of the coast counties on the west ranges from 60 to 130 inches per annum, and the Puget Sound area has from 20 to 55 inches, while the western slope of the Cascades receives over 100 inches of precipitation annually. On the summits of the Cascades as well as the foothills the greater part of the precipitation is from the snowfall of winter, and the summer rainfall is light.

As the water does not all run off in the wet season of the winter a large part is stored up in the form of snow and ice and it is this moisture that feeds the supply of water that seems to be very large and is reached by deep wells and by springs in the vicinity of Tacoma.

GEOLOGY

An examination into the geology of the Puget Sound Basin discloses that the area has undergone profound changes. The shore

lines have been altered, valleys and mountains have been formed, and although the developments have taken centuries it is necessary to summarize the changes in a few words.

With the exception of the Cascade Mountains and their foot-hills the country is mostly a rolling, glaciated plain, with elevations ranging from 200 feet near the shore line to 600 feet at the foot-hills, cut into alternate ridges and valleys by the erosive action of former glaciers and recent streams. A large depression in this plain, probably the work of erosion, is the region known as the Puget Sound Basin. The body of water now called Puget Sound is a long and tortuous arm of the sea extending far inland and occupying a large portion of the basin to which it gives its name. It is believed by geologists to be a "drowned" valley, caused by an influx of the sea as depression took place in the land.

The high ranges of mountains appear to be remnants of a long plateau and the lower hills formed by stream and glacial erosion. The high mountain peaks are of volcanic origin and are not integral parts of the ranges. The Cascades of today are not to be regarded as the first generation of mountains that existed in their location, but might be classed as the successors of others that had their own long period of history and which were gradually eroded by Nature's agent.

The Cascade Mountains came into existence through the action of the great earth forces bringing up immense thicknesses of rock and they have been subjected to extremes of weather such as rain-wash, stream erosion, frost and sun action for centuries. This weathering of the rocks caused a rugged crest line and, although the valleys have been filling up, the Cascades still stand as the main mountain range of the State of Washington.

After the Cascades were folded a general depression took place along their west base, and a large river system is thought to have been formed that helped to make the depression deeper and deeper.

About this time the climate seemed to change and the snowfall accumulated until it assumed such immense proportions that a movement was started and a huge glacier swept down from the north and filled the area known as Puget Sound Drainage Area as far south as Tenino or a few miles south of Olympia. As this glacier swept down from British Columbia it filled the Straight of Juan de Fuca and might have extended out to sea. The bare rock surfaces of the San Juan Islands preserve many of these markings and in nearly all cases they tread from north to south.

TABLE 1

Deep wells—South Tacoma wells, City of Tacoma

	WELL 1	WELL 2	WELL 3	WELL 4	WELL 5	WELL 6	WELL 7	WELL 8	WELL 9	WELL 10	WELL 11	WELL 13	WELL 14	WELL 15
Sizes of well casing, inches..	11⅝	10	10	7	10	10	12	10	12	10	14–12–11⅝	9¾	10	10
Elevation of surface of ground, feet.....	282.1	283.7	285.5	286.3	286.3	288.8	286.2	286.5	275.3	289.8	284.2	288.2	287.8	282.9
Elevation of static water level June, 1928, feet.....	249.3	248.8	249.1	248.5	246.7	247.0	250.3	250.5	250.8	249.0	246.4	249.5	250.5	246.6
Distance of static water level below surface, feet.....	32.8	34.9	36.4	37.8	39.6	41.8	35.9	36	24.5	40.8	37.8	38.7	37.3	36.3
Depth of well, feet.....	118	123	175	176	236	205	124	151	149	205	192	229	209	205
Flow of water—pumping, m.g.d.....	1.25	0.75	1.25	1.5	1.25	2.5	0.75	1.25	1.00	2.00	4.75	2.00	2.00	2.20
Drawdown below static water level while pumping, feet.....	23		40		40	42		46	40	21	23	26	60	

The ice is known to have been of sufficient thickness to fill the troughs of Puget Sound and to have overtopped small mountains over 3,000 feet in height. The ice sheet must have been considerably thicker than this in order to generate the necessary motion to over-ride the rough surface of the area as existed at that time.

The changes in climate probably caused the retreat of the glacier and the melting of the ice must have been very gradual as by degrees the glacial front retreated and great floods of water, constantly fed by newly fallen snow, carried enormous quantities of silt, sand and gravel in the streams. This glacier might have advanced and retreated several times and each movement piled up great quantities

TABLE 2

Deep wells—South Tacoma and Prairie Country

WELL OWNER	ELEVATION	DEPTH OF WELL	FLOW	SIZE OF CASING	DISTANCE OF STATIC WATER LEVEL BELOW SURFACE
	feet	*feet*	*gallons per day*	*inches*	*feet*
Regents Park	260	220	100,000	12,10,8	10
Calvary Cemetery	265	165		8,6	25
South Tacoma Mill Company	260	98		12,10,8	30
Tacoma Land Company	275	180	360,000	12,10,8	15
Du Pont Company:					
Well Number 1	251	367	360,000	12,10	29.7
Well Number 2	244	127	360,000	12	20
Well Number 3	208	130	55,000	12	45

of gravel and other material. This material was sometimes worn down to very small dimensions as the grinding process took place and the debris was carried great distances.

The great gravel benches now existing in this area represent the remnants of enormous fills in the valleys. The deposits of gravel in the Fort Lewis area and the prairie country south of Tacoma was left by a huge river that was thought to have flowed from the lake that existed somewhat above where the town of Puyallup now stands. Lake Puyallup was about 400 feet above sea-level as we know it at the present time. At this time the rushing waters were carried on to the south toward Olympia and the great gravel benches in the Chehalis River area were formed at this time as the stream flowed to the ocean through Grays Harbor.

The area now occupied by Tacoma was covered by the huge glacier and it was impossible for any of the water to find its way to the north. As the ice retreated the area as far north as Point Defiance was uncovered and the level of Lake Puyallup was lowered as the water was diverted along the Clover Creek channel and later down the De Lin Street route.

A huge lake called Lake Russell was known to cover all the area of the Puget Sound Drainage Area now occupied by Puget Sound north of Olympia. As the glacier retreated to the north this lake

TABLE 3

Deep wells—Tide Flat Area—Tacoma

WELL OWNER	ELEVATION	DEPTH OF WELL	ARTESIAN FLOW	PUMPING FLOW	SIZE OF CASING
	feet	*feet*	*gallons per day*	*gallons per day*	*inches*
Sperry Flour Company:					
Well Number 1	25	150	115,200	70,000	
Well Number 2	25	350	100,000	288,000	12,10,8
Well Number 3	25	540	200,000	432,000	12,10,8
Carstens Packing Company	25	452	200,000	500,000	12,10,8
Tacoma Fir Door Company	25	318	100,000		12,10,8
Wheeler-Osgood Company:					
Saw Mill	25	493	43,200	115,000	10,8
Door Factory	25	392	100,000	450,000	10,8
Buffelen Lumber and Manufacturing Company	25	856	468,000		18,12
City of Tacoma	25	755	275,000	1,500,000	24,18,12½

became larger until it reached the straights and then the waters of Puget Sound were changed from fresh to salt water.

The lakes south of Tacoma were formed when the ice melted in irregular shapes and perhaps a new deposit of gravel was left and the final retreat of the ice caused the melting of the entire deposit so that irregular depressions were formed and they became the basins of the present lakes. The lakes are at different elevations and do not seem to have any connection with each other.

GROUND WATER

The records of the deep wells in the Tacoma district all show large deposits of water bearing gravel that are fed from the higher altitudes.

The water moves under forces of gravity from higher to lower levels and as it circulates through the small voids and openings it moves much more slowly than the surface water.

Considerable of the precipitation becomes ground water and as the snow melts slowly and evaporation is moderate due to the cool summers, the run off is fairly distributed throughout the year. Of course, the flow varies with the nature of the topography and character of the underlying structures and other conditions.

TABLE 4

Deep wells

WELL OWNER	ELEVATION	DEPTH OF WELL	PUMPING FLOW	SIZE OF CASING	DISTANCE OF STATIC WATER LEVEL BELOW SURFACE
	feet	*feet*	*gallons per day*	*inches*	*feet*
DeLynn Street Gulch Area					
National Soap Company:					
Number 1	150	200	144,000	12,10,8	50
Number 2	150	435	144,000	12,10,8	50
Columbia Brewing Company	140	150	258,000	12,10,8	40
Division Avenue Area					
Matthaei Baking Company	388	396	72,000	10,8,6	80
Horsehead Bay Area					
			ARTESIAN FLOW		
MacAllaster Moore	11	604	Low tide, 8,600 High tide, 14,400	6,4½,3	

WATER TABLE

The surface of the earth that is saturated with ground water is called the water table or the ground water level. It curves upward under the hills and downward beneath the valleys. The depth to the water table is greater on the hills and less in the valleys, due to the ground water continually sinking and flowing away from the higher altitudes, while in the lower areas it is frequently rising and being discharged.

The deep wells on the tide flat area of Tacoma are all flowing wells. The two wells that are owned by the City of Tacoma and the Buffelen Lumber and Manufacturing Company both reach a large supply of water at 700 or 800 feet below sea-level. A gravel formation that is water bearing was found at about the 500 foot below although the supply of water was not so great. In connection with both of these wells it is interesting to note that well preserved logs were found in the 700 foot level below the sea.

The Wheeler-Osgood wells on the west side of the tideflats found flowing water at about 400 feet depth.

Wherever a thick deposit of gravel is found in this area one is sure to uncover a supply of water.

The water table on the prairie district is fairly near the surface of the ground although the near surface supply is not very reliable during the dry summer and fall. The reliable supply of water seems to be at least 60 feet below the surface, but any depth over 100 to 200 or 300 feet finds a supply that is constant at all times during the year. The logs of the Du Pont wells are very interesting.

The wells of the City of Tacoma seem to reach a supply of water that is very great and the pumping equipment that is available for use seems to be the measure of the amount of water that they can secure, at not over 100 feet below the surface.

The Matthaei well finds water at about sea-level and the log on the formations show that the deposits of clay, sand and gravel seem to be in fairly thin layers.

Near Arletta Mr. Moore has found a supply of water at about 600 feet below sea-level and the supply seems to come from the deep layers of water bearing material below the Sound.

The large springs near Tacoma are all very interesting and they seem to show that great quantities of water drain out from the gravel beds beneath the city.

LARGE SPRINGS NEAR TACOMA

Mason's Gulch Springs

The supply of water from these springs was formerly used by the Tacoma Water Supply Company, which has been purchased by the City of Tacoma.

These springs are distributed around the margin of Mason's Gulch, and they have a combined capacity of about 2,000,000 gallons per day. Mason's Gulch extends from the intersection of North

37th and Stevens Streets in a northeasterly direction to Commencement Bay.

The water from these springs finds its way to the surface in two layers of hardpan at elevation of 120 and 205 feet, respectively, above sea-level. The water is collected together in a receiving reservoir and is pumped to the reservoir at a higher elevation.

The faces of the water-bearing strata are generally covered with slides from the sides of the gulch and the springs are developed by digging galleries into the side hill or by driving 2-inch sand points horizontally into water-bearing strata of the slope. The springs will probably yield considerably more water with further development.

Fort Lewis Water Supply-Springs near Sequalitchew Lake

Nearly 5,000,000 gallons of water per day have been supplied from these springs during the war and the water seems to be very pure.

The source of this water is a sufficient distance away as it is entirely free from bacteria and has no near surface connection. There is but little fluctuation in the flow during the wet and dry seasons.

Maplewood Springs

These springs are located near Puyallup in Section 32, Township 20 North, Range 4 East. The water issues in streams from beds of gravel at the base of a bluff.

The flow is estimated at 11,000,000 gallons per day and the springs are owned by the City of Tacoma.

Steilacoom Springs

The water from the town of Steilacoom is supplied from springs that are about a mile from the city limits near Du Pont. The elevation of the source of water is about 275 feet above sea-level.

Western State Hospital Springs

These springs are located on the hospital grounds near the top of the hill and the flow is estimated at about 2,000,000 gallons per day. This supply is used by the Cascade Paper Company in the manufacture of pulp and paper.

The flow decreases in the late summer and does not become normal again until late in the fall during December. This shows that the source of supply is a great distance from the outlet as the early fall rains do not increase the flow of water.

South Tacoma Wells

These wells were drilled by the City of Tacoma along the line of the old Clover Creek Flume during the period from 1903 to 1909. They are located on Clament Avenue between South 62nd and South 76th Streets, Tacoma, and until the completion of the Green River Gravity Line constituted the principal source of supply for the city. They are now maintained as an emergency supply and help out to carry the peak load during the sprinkling season.

The water stands in the wells at about 35 feet below the ground surface. There were originally eighteen wells, but four of them have been abandoned. The remaining fourteen wells are equipped with air lifts, and the present compressor equipment can supply about 13,000,000 gallons per day.

Several of these wells have been inactive for several years and a recent inspection by city officials found the air lift equipment filled with rocks and miscellaneous debris. As soon as the wells were cleaned out their supply of water seemed to be the same as existed several years ago.

No log of the formations was ever recorded of these wells, but a recent test by the owners revealed different and well separated water strata at two different elevations. This would show that wells of different depths could be drilled without the flow of each one interfering with the other to any great extent.

A recent test made by the City of Tacoma shows that a much larger amount of water may be obtained from the wells at a final draw down of not over 60 feet below the present static water level or not over 100 feet below the ground level.

QUALITY OF UNDERGROUND WATER

As analysis has been made by several owners of wells and springs and in every case the water has been excellent for both industrial and domestic use.

CONCLUSIONS

The author believes that large quantities of pure water are available for use in the district covered by this paper. The low cost of electric power in the vicinity makes the cost of pumping water very low as compared with other sections of the country.

Where water has to be brought great distances and the investment

in pipe lines is very great, the cost of delivering water that is pumped from wells would be less than from any other supply.

Several of the industries on the tide flats have drilled wells at a lower cost than they can purchase the water from other sources and the owners are of the opinion that it is a good investment.

It has been impossible to secure the logs of several of the older wells. The State of Washington should attempt to secure any information along this line while it is available. In several cases the land on which the wells are located has been sold and all records are lost.

No legislation on underground water rights in this state has ever been passed by the legislature as the need for laws on this subject has not been great. As these natural resources are developed, it will no doubt be necessary to have appropriate legislation.

WATER RESOURCES ACTIVITIES IN NORTH CAROLINA[1]

By Charles E. Ray, Jr.[2]

The purpose of this presentation is to give a report of the water resources activities being prosecuted in North Carolina and to discuss certain of these activities in an informal way. The opportunity to do this has been given the author by Thorndike Saville, Chief Engineer of the Department of Conservation and Development, who delivered an address of the same general nature before the Section at its Raleigh meeting. This paper is largely an expression of that address to which supplementary data have been added.

In name and in fact the Division of Water Resources and Engineering is primarily concerned with the Water Resources of the State, and it is dedicated to their development and conservation for the people of North Carolina. In rendering this service, the Division is closer to the natural resource than it is to the people. To a large extent others must take the data in the form in which they are prepared by the Division, and interpret and apply them to the solution of the municipal, industrial, and public health problems of the State. This middleman function is the job of the water works and sewage men, the engineer, and the chemist. It is equally the duty of the middleman to utilize these basic data to the fullest extent for the benefit of the people, and to insist that governmental agencies adequately equipped should be provided to span the years with basic investigations—to the end that the basic information necessary to the proper solution of our growth problems may be provided.

The basic investigations at present being prosecuted by the Division are divided into several interrelated groups which for purposes of financing and prosecution are handled as projects. These comprise:

1. Stream gaging
2. Power studies

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[1] Presented before the North Carolina Section meeting, November 19, 1928.

[2] Principal Assistant Engineer, Department of Conservation and Development, Chapel Hill, N. C.

3. Hydrologic investigations
4. Costal studies
5. Stream sanitation and conservation
6. Chemical water analysis
7. Drainage
8. Underground water investigations
9. Mapping

Stream gaging was the first activity to which the Division turned its attention. It has remained the major activity. Measured in terms of funds and personal service devoted to it, over half of the Division's efforts are directed to its prosecution. The first stream gaging station was established on the Yadkin River near Salisbury by the United States Geological Survey in 1895. From that date until 1920, the Survey carried on the work in the State unassisted by any State agency. It was operating only eight stations at that time and none of them were of the recording type. In that year North Carolina officially recognized stream gaging as a governmental function worthy of State support by the creation of this Division with a small appropriation for stream gaging and other water resources investigations. A coöperative agreement was executed between the Division and the United States Geological Survey whereby the stream gaging funds of both agencies were pooled for the joint prosecution of the work; the Survey being the responsible agency for conducing the field operations and issuing the basic tables of daily flow which involve extensive office work; the Division being the responsible agency for analyzing and indicating the stream gaging needs of the State, maintaining all official coöperative contacts and relations with parties to stream gaging contracts, formal or informal, except where the coöperative party is a Federal agency, and for handling the assimilation and publication of the stream flow data for the use of the public. This coöperative relation between the Division and the Survey is still in effect. The Division prosecutes its work from its office in Chapel Hill under the general supervision of the Director of the Department. The United States Geological Survey prosecutes its work from a jointly maintained office in Asheville under the direction of a District Engineer of the Survey. Necessarily, the relations of the two offices are very close.

ACTIVITIES OTHER THAN STREAM GAGING

In this report attention will be devoted chiefly to stream gaging. It is pertinent, however, to call attention at this point to other related

activities before continuing with a consideration of stream gaging. The laws under which the Division operates are quite broad, and they impose many responsibilities on the Division. Limited appropriations have always placed a rather definite limit on the extent of total operations and it has been the policy of the Chief Engineer to concentrate on a limited number of activities rather than to spread out into many. However, with the growth of the State, many imperative needs for the services of the Division have developed and adherence to this policy has been extremely difficult, even though appropriations have not kept pace with service requirements.

Power studies. Hydro-electric power developments have been a large contributory factor to the development of the State. Stream flow data were the basic information which they required before proper development could take place. It was to serve that need that the first stream gaging stations were established and operated. In addition, interested parties made demand on the State for other data on rivers, which necessitated power studies by the Division. In recent years, very little field work has been prosecuted by the Division in this connection, except that a number of stream gaging stations are still being operated with the support of the power companies because of their power relation. Recognition came to the Division as the principal source of information in the State on power and it has been necessary to continue files of power data and statistical studies. The Division is also the official State agency for coöperating with the Federal Power Commission, and this entails certain responsibilities. Power studies were an outgrowth of stream gaging, and it is pertinent in this connection to point out that as the first stream gaging stations installed were for the purpose of furnishing data on the potential power of large streams, all of the long stream flow records which we have are for large rivers in the west-central or western part of the State. They have and still are serving a worthy purpose, yet they are not the records now badly needed on small streams in connection with water supply and stream conservation problems.

Hydrologic studies. Complete files have been maintained for years of all the printed hydrologic data relating to the State, and as much of the unpublished data as could be obtained. The United States Weather Bureau is the principal source of these data. The manner in which they publish the data does not permit their fullest use, however, except by those agencies which receive and maintain

files of the monthly, annual, and section summaries, and there are certain needed data which the Bureau does not obtain even at its fully equipped stations. There are also certain areas where even the ordinary data are not obtained, but are needed. The work of the Division is complementary to that of the Weather Bureau, and in certain fields is an extension. In certain instances the Division coöperates with the Bureau in the operation of stations. At present, the Division is responsible for the operation of 11 stations. Rainfall records are being maintained at all of them; evaporation is being measured in three instances, from floating pans exposed in lakes in two cases and from a land pan in another; humidity records are maintained in two instances; and wind movement and surface water temperature records are being maintained at three of them. It is expected that all of these stations will provide special data of much value.

A bulletin is in preparation on the rainfall of North Carolina which should prove of much value to the engineer and others concerned with rainfall and water resources. It is planned to follow this bulletin with a sister publication on temperatures. Special studies will be reported as they can be completed.

Coastal investigations. This investigation very recently undertaken has special features of interest to the members of the Association from the east. It comprises, in part, related matters of stream flow, general hydrological elements, chemical character of surface waters, salinities of sound and tidal waters, availability and character of underground waters, and drainage. Much basic information concerning the resources of Eastern North Carolina must be obtained before it can hope for that extensive development of which it is so splendidly capable.

Stream sanitation and conservation. The problem of conserving our streams in the sense of maintaining them in a proper sanitary condition so that each individual stream may be made to yield its most important uses to the State is a large one and of first order importance. In the prosecution of this work the Department coöperates with the State Board of Health through a joint committee.

Chemical water analysis. To meet the extensive demand for information made of the Department concerning the chemical quality of water in the State with regard to its industrial suitability, a large number of samples of water have been analyzed through arrangements made by the Division. Formerly the analytical work was

done by the United States Geological Survey, but under present arrangements, this work is being done for the Division in the laboratory of the Bureau of Sanitary Engineering of the State Board of Health.

Underground water investigations. This is a project being actively recommended, but not prosecuted as yet by the Division. A detailed outline of the work needed has been prepared, and the cooperation of the United States Geological Survey has been assured for the next two years on a fifty-fifty basis, the Survey to make the investigation if State funds can be made available.

Other related projects. Drainage and mapping will be mentioned only. Both of these projects are part of the Division's concern, but it is not able to do more than to keep them alive. The relationship with drainage will be obvious. The law places certain responsibility on the Division in connection with Drainage Districts. Mapping is of concern because the topographic map of North Carolina is only 36 per cent complete and it is greatly needed for every area where water resources activities are prosecuted.

STREAM FLOW RECORDS FUNDAMENTAL AND NECESSARY

Brief mention has been made of the several interrelated projects being prosecuted by the Division. It has been stated that stream gaging was the major activity. It is also the most fundamental activity. The actual process of gaging the flow of streams, measuring their ever changing flow to the end of providing reliable records, is an engineering art. A stream gaging engineer is not an academic product but a field development. A stream gaging record is not a guess as to the flow resulting from a casual observation, but a carefully prepared statement of the flow day by day, year after year. Such a record evolves only from an enormous amount of work; work in the field, fields of mud or ice, roads or mountain paths long and weary, times of floods and any time; work in the office computing discharge measurements, preparing rating curves, checking gage heights and flows, tabulating and checking, checking again, preparing station descriptions and reports, all of these things and more. The final product, the record, is a tabulation of figures, uninteresting to the average man. Yet it tells a story of importance to the fast growing city anxious in regard to its water supply, and with regard to the disposal of increasing volumes of domestic and industrial wastes. The men charged with the responsibility of supplying North

Carolina with potable water on the one hand and disposing of her wastes on the other, see more than the figures. They tell how much water can be realized from the stream in times of drought such as North Carolina experienced during the summers of 1925 and 1926. They tell how much water will be available in ordinary times, how much storage should be provided to prevent failure of supply, how much waste can be safely carried by the stream, and many other important facts. The existence of a comprehensive record of the flow of a stream to be developed for a water supply, or for power or other purposes or to be utilized in any way, reduces the solution of such problems from guesswork and uncertainty to one of mathematical certainty. It may mean all the difference between a fully adequate and a totally inadequate supply. Such a record will prevent both under and over-development. It may prevent the unwise expenditure of thousands of dollars. It may mean that the bridge will remain tomorrow where it was yesterday. The absence of a comprehensive record may cause the result to be almost anything. If these things are true it is pertinent that we should inquire into the adequacy of the stream gaging operations being prosecuted in North Carolina.

EXTENT AND ADEQUACY OF STREAM GAGING

Attention is directed to table 1, where is set forth a condensed report of stream gaging operations in North Carolina as of January 1, 1929. Sixty-seven gaging stations are being operated on 53 different streams. Of that number, 36 are equipped with recorders giving continuous records of flow. The importance of such records will be discussed later. Sixty-four stations established in times past and operated for a period of time, have been discontinued. In all, 131 records of different degrees of value are available. That number may seem large at a first consideration. Considering the needs of the State as a whole and the individual records, it is woefully small.

There are 13 major river basins in the State. These are listed in table 1, and the data is arranged by river basins. The Cape Fear River Basin has 15 active stations and of these, 12 are equipped with recorders. No station has ever been operated in either the Watauga or the Savannah River Basins in this State. Between these two extremes, we have various numbers, although no basin with the exception of the French Broad, which has 13 stations, has more than 9 active stations.

Consider the Tar River Basin with 3100 square miles in area. One station was operated at Tarboro during the period 1897–1900, four years, and that record contains about all that we know of the flow of the Tar River. In the fall of 1928, Army Engineer funds were made available in sufficient amount to permit the establishment of a non-recording station on the Tar River near Nashville, and another

TABLE 1

Condensed report of stream gaging operations in North Carolina, January 1, 1929

RIVER BASIN	ACTIVE STATIONS	ACTIVE STATIONS EQUIPPED WITH RECORDERS	DISCONTINUED STATIONS	NUMBER OF RECORDS AVAILABLE	AVERAGE SIZE DRAINAGE AREA ABOVE STATION	LONGEST RECORD IN BASIN	STATION
						years	
Roanoke	2	1	4	6	4,445	17	Roanoke at Old Gaston
Tar	2	0	1	3		4	Tar at Tarboro
Neuse	9	5	3	12	324	4	Neuse at Selma
Cape Fear	15	12	5	20	1,395	28†	Cape Fear at Fayetteville
Yadkin	5	3	7	12	2,187	32	Yadkin at Salisbury
Catawba	4	2	12	16	323	6	Linville at Branch
Broad	3	3	5	8	188	3	Second Broad at Cliffside
Savannah	0	0	0	0			
New	2	0	4	6	231	8	S. Fk. New at Crumpler
Watauga	0	0	0	0			
French Broad	13*	6	11	24	192	31†	French Broad at Asheville
Little Tennessee	9	3	9	18	289	32	Little Tennessee at Judson
Hiwassee	3	1	3	6	176	32	Hiwassee at Murphy
Total	67*	36	64	131	9,750	197	
Average	5	3	5	10	750	15	

* One station operated by Chattanooga office, United States Geological Survey.

† Record not continuous from date of first operation.

one on Fishing Creek near Enfield. The drainage areas above these stations are 695 and 462 square miles respectively. Considering the total area of the basin containing the two stations, there is one active station for every 1550 square miles. There is not and there has never been a station on a small stream such as most towns in the Tar River Basin must utilize.

Consider the Yadkin River Basin having an area of 8642 square miles in North Carolina. There are 5 active and 7 discontinued stations. The average size of the drainage area above the twelve stations is 2187 square miles. Only one active station measures the flow from an area of less than 250 square miles. In one respect, however, this basin is peculiarly fortunate. The flow of the Yadkin River was measured at a station near Salisbury for a period of over thirty-two years. It is the longest and most valuable record of stream flow for a North Carolina River, spanning the period 1896–1927, and has been referred to as a base record many times. The abandonment of the station was caused by backwater from the High Rock Dam. Similar information concerning each basin can be obtained by reference to table 1.

It is important to note two further facts brought out by the table. The average size of the drainage area from which the yield has been measured is 750 square miles; this compared with the fact that most of the streams utilized by municipalities have drainage areas of less than 25 to 50 square miles. Considering the longest record available for each major basin, the average length of record is only fifteen years. The average length considering all of the available records has not been computed, but the average is about five years; this compared with the fact that a record ten years in length does not usually show the extremes of flow, and that the extreme droughts and extreme floods shown in a twenty-five-year record cannot be accepted as final.

Several conclusions may be drawn at this point:

1. Practically all of the stations now in operation should be continued for a number of years. Some of these should be equipped with recorders.

2. Records should be started at recorder equipped stations on a group of carefully selected small streams having drainage areas of 5 and 10 to 25 square miles. These would provide information on the type of stream most often resorted to for municipal use.

3. Although not following from any evidence presented in the table, stations should be established on a number of large streams for which no record is now available. Among these are included, the Lumber, Uharie, Northeast Cape Fear, and Watauga rivers, the Little River near Troy, the Tar River near Greenville, the South Fork Catawba, and other rivers; McAlpine Creek near Charlotte, Batchelder Creek near New Bern, Hunting Creek in Davie County, and others.

In the accomplishment of this program we face the difficult fact that neither the State nor the Federal government has appropriated funds for the purpose. Will private coöperation provide funds?

COÖPERATIVE SUPPORT AND THE FUTURE EXPANSION OF STREAM GAGING

Although additional stations are needed it is with pride that the Division reports to the Association and to the State that 67 stream

TABLE 2

Coöperation in stream gaging in North Carolina, January 1, 1929

Active Stations—67.

In coöperation with:	
1. Municipalities—22	
a. Maintenance, and in some instances, establishment	15
b. Establishment only	7
2. Chattanooga District Office Army Engineers—14	
a. Maintenance, and in some instances, establishment	14
b. Establishment only	0
3. Wilmington District Office Army Engineers—6	
a. Maintenance, and in some instances, establishment	6
b. Establishment only	0
4. Federal Power Permittees—4	
a. Maintenance, and in some instances, establishment	4
b. Establishment only	0
5. Private Power Companies—6	
a. Maintenance, and in some instances, establishment	4
b. Establishment only	2
6. Industry and Individuals—5	
a. Maintenance, and in some instances, establishment	2
b. Establishment only	3
Total of stations operated receiving some degree of coöperative support	57
Stations supported entirely by United States Geological Survey and Water Resources and Engineering Division	9
Total stations coöperatively operated by Asheville office, United States Geological Survey and Water Resources and Engineering Division	66
Stations operated by Chattanooga office, United States Geological Survey	1
Total gaging stations operated in North Carolina	67

gaging stations are being operated at this time; that 36 of them are recorder equipped. It is the largest number ever in operation. It is an accomplishment that has been made possible only through financial and personal coöperation.

Looking back to 1926, we find a critical condition. Stations had been established where they were most urgently needed in the hope

that adequate appropriation funds could be secured for their operation. This had been going on year after year, the station load always being in excess of immediately available funds.

The crisis was reached in 1926. On September 30, fifteen stations were discontinued. On January 1, 1927, only 39 stations were being operated. In the face of that condition, the needs for additional stations became greater than ever. There was only one answer. The party needing the data had to assume a greater share of the cost. The few additional stations that could be added with available funds were established during 1927 and 46 stations were being operated by January 1, 1928, and that was the limit. Still there were problems demanding solution which required the establishment of gaging stations. There was only one answer, the coöperating party had to bear all of the cost of installing the station and its operation. On this basis 22 stations were installed during 1928. The new work could be handled only by the employment of an additional engineer whose entire salary had to be cared for out of the station funds.

The extent to which stream gaging is receiving financial support is indicated in table 2. It is pertinent to point out that of the 67 stations being operated by this Division in coöperation with the United States Geological Survey, 57 have been established through coöperation, and 45 are receiving annual support. Only nine stations are supported entirely by the Division and the Survey.

During the present fiscal year, the Division and the Survey will spend approximately $20,000 of appropriation funds on stream gaging, $10,000 of private coöperation funds, and probably $6000 of Army Engineer and Federal Power Permittee funds, a total of $36,000. Of the $20,000 listed above, $15,000 will come from the Division's State appropriation.

WATER SERVICES[1]

By D. T. Salmon[2]

The service connections of an up-to-date water works plant are an important part of its equipment. The question often arises as to the proper size service and the quality of material to be used. With these two questions settled a water works plant is well on its way to a relief from one of its real worries and to the realization of having satisfied consumers. In Fort Wayne, we have a great number of consumers who we know are not entirely satisfied. This dissatisfaction is caused, mostly, by the fact that this detail was not given proper consideration in past years.

In our own plant, we have, for residences and stores, a number of services only ½-inch in diameter; a large number of ⅝-inch and quite a few ¾-inch "Y's." The latter was an invention, in so far as we are concerned, of about the year 1912. Of course, we have a goodly number of larger sized services, but it is not with these we have to worry.

The ½-inch service should never have been thought of, but when it was thought of, it should have been to prompt the management to the study of details which would result, promptly, not only in its abandonment, but in looking into the future in such a way that the size to be then adopted would be sufficient to give satisfaction for the balance of time. But here details were still overlooked, for the size then to be adopted was only increased to ⅝-inch. We know now that the ⅝-inch service is also too small.

Then came the ¾-inch "Y" and another source of annoyance was added to our list. The ¾-inch "Y," has two ⅝-inch branches extending from a ¾-inch stem, from the main on the property line and each branch serves a separate lot. These services were mostly placed at curb lines on vacant lots and ahead of new pavements and were expected to be labor-saving at the time of their installation, for it only required one trench for the two "Y" branches. On the other hand, this would only bring the water to the corner of the lot and

[1] Presented before the Indiana Section meeting, February 27, 1929.

[2] Auditor, Water Works, Fort Wayne, Ind.

quite often cause the consumer to run a longer line into the house. Sometimes these "Y" services would be run in for lots as great as fifty feet wide; then, in a number of cases, these two large lots would be divided into three smaller ones. This would give the two branches to one lot and leave the other two without any line.

While this method might have been labor saving when installing, it certainly was not trouble saving in operation. When two consumers get on the same "Y" service then the trouble begins, for, when both happen to be using water at the same time, both are affected in so far as their supply is concerned. Then, again, at any time, but more so in the night, when one consumer opens his line a rumbling noise can be heard very plainly and quite often disturbingly, in the other house. While all these installations have been abandoned by our department, we still have the army in the field, active participants in their line of trouble.

Our new building code, effective January 1, 1927, provides that no water service shall be installed with a diameter less than $\frac{3}{4}$ of an inch; that no more than one meter shall be placed on one service, and a thorough inspection must be made by the building department.

In the old days we had many cases where one owner built two houses on one lot. It would be the custom to run in one $\frac{5}{8}$-inch service to supply both. Of course, while the owner was paying the water bills, it did not mean so much, but later on when these two houses would be sold to different owners, there was sure to be trouble.

What a glorious thing it would be if each consumer, in the past, had been provided with a 1-inch service line extending from the main line in the street to the cellar.

That the proper sized service contributes to the health of your consumers is also evidenced by the fact that a full flow of water tends to empty the pipes from any sediment that may collect during the time the water was not running, and to give a wholesome drink to the consumer without any unnecessary delay. The smaller sized services also have a tendency to collect sediment more readily than the larger. Thus from an early date they are declining in efficiency.

Who ever heard of a water service too large? But what day passes that we do not hear an appeal from one or more of our consumers as to why they cannot get a sufficient supply of water for ordinary purposes. It is often our painful duty to say to them that the only method they can pursue in order to get an adequate supply of water is to order and pay for a new and larger service, not only from the

main line to the curb, but extending through the property and into the house. This expense is certainly a burden to consumers which could have been prevented.

It is important that consumers should have at their command a much greater supply of water than that used for ordinary purposes. When, in case of fire, or other emergencies, it becomes necessary to have a bucket or tub of water in a short space of time, the service should be large enough to supply it.

LENGTH OF SERVICE

It has always been our custom, not to place the mains in the middle of the street, but nearer to one side. This, of course, gives a short haul to properties on one side of the street and a much longer one to properties on the other side. We have a few lines in the parking inside the curb, and a few in easements in the rear of the lots. The latter is done only to conform with the plans of the promoters of new additions. When the main lines are in the parking or even on one side of the street, the same sized service has a tendency to give the properties on the short side the best of the deal. Would it not have been more equitable to give the property on the long side, especially when the smaller sized services were being placed, a slightly larger service than the one on the short side?

Our charges for services are based on the mains being in the middle of the street. We feel that this is justifiable in all sized services for it would not be fair to consumers to have one pay more for the same size than another, merely because he is not located on the right side. When the mains are in the parking, between the sidewalk and curb, it is only necessary to run curb lines to the opposite side ahead of pavements, leaving the other side open until services are ordered. When the lines are in easements in the rear of lots no curb lines are necessary, the question of services being left open until the owner places his order.

The water services should be and usually are under the jurisdiction of the water department. This method places a responsibility upon the department that should be looked after carefully, not only to see that the connections to the mains are properly made, but that the correct sized service be put in. That consumers do sometimes get and are obliged to pay for a water service that is not suitable to their needs, is obvious on different occasions. There can be no objections to the remainder of the line being placed by private contract, but under the supervision of either the water or building department.

It is not always the case that proper care is exercised in giving efficient service and wholesome water to properties in new additions, especially where homes are being built to be sold. These homes are naturally built to be sold at a profit and to make them as attractive as possible at the lowest possible expense is likely the one objective of the promoter. When an agent is able to say that his houses are provided with city water, then he presents an advantage that appeals to the purchaser. But we all know that this part of the agreement is not always exactly what the prospective purchaser imagines it to be. Small sized services naturally cost less money; sometimes the supply comes from a dead end of the line, and sometimes, in the days of the past, promoters would insist on having only one small service to supply a number of houses; or one small service to run a long way down the curb to supply a house not located on the mains. This is all wrong and while it promotes properties at the time they are built, it only adds another trouble for the department and the consumers, which is bound to show up in the future.

SERVICES IN ADVANCE OF PAVING

We formerly placed curb line services ahead of new pavements without any method of collecting for them other than waiting, sometimes for years and sometimes forever, for them to be placed in use. Then we would have to insist on payment before we would allow the water to be turned on. This very often worked a hardship on a new consumer and usually caused dissatisfaction at the beginning. It also gave the original owner the advantage of sale price of his lot, by having city water to the curb, and leaving the payment of the curb line service to the latest buyer who had already bought the lot at the advanced price. We now have at least $15,000.00 of these unpaid curb lines on our books.

In 1915 this method was changed. While we continue to go in ahead of new pavements and place curb line services on vacant lots, we only give the present owner of the lot an opportunity of paying for same at once, otherwise the cost is added to the assessment rolls. These curb lines are now $\frac{3}{4}$-inch in diameter unless larger ones are asked for by the lot owner.

Care should be taken to place service lines deep enough to prevent them from freezing. This precaution is usually taken at the time of installation, but there are times later on when a different grade is

called for on the street and thus sometimes the service line is brought too close to the surface.

Stop boxes on services are not intended to be ornamental or otherwise, but if they cannot be ornamental they certainly should not be permitted to be otherwise. The days of the hitching post have passed into the record of ancient history and while we have a few left that could be used very handily for that purpose, their elimination has been going on for sometime. Some day soon we hope to deprive the boys completely of their former pleasure of using some of them in their game of leap-frog.

Old and inadequate services when abandoned should be disconnected at the corporation when it is possible to do so, but in many cases this would entail a considerable expense because so many of them are under paved streets. These abandoned services sometimes give trouble later on, but the trouble is not sufficient to justify the expense of removing all of them. Removing the stop-box and shutting off at the curb cock are about all that is usually done.

LOCATION RECORDS

For a number of years we did not have a systematic record for the location of services. The placing of curb lines was left almost entirely to the judgment of our construction department, who had very little to go by for direction. In fact some of the returns came in telling us that a curb line had been placed on the first, second, or third lot east, west, north or south of a certain street; that one had been placed a number of feet distant from a certain tree or that a big rock was close by. Some records would give us the lot number only and some would give what they thought the house number ought to be, without reference to the lot number.

But this has all been improved and for a number of years we have had a complete record of every service placed. By the system now in use we can give the exact location of every service placed from our special office record. This is accomplished by having a print drawn of the street to be improved showing the location of the main; the width and depth of each lot, their number and addition. Then a stake is driven showing the exact spot where the line is to be run. The exact distance measurements are then transferred to a special service card and placed in files according to street and number.

MATERIAL FOR SERVICES

The material used in service lines has never caused us much concern. Extra strong lead, as far as I can learn, has always been the material with brass corporations and curb cocks; our own plumbers wiping the two joints necessary as far as the curb. Trouble on our service lines from the main line in the street to the curb is very rare, considering that we have more than 30,000 connections of this material in different kinds of soil. In fact, service No. I, placed by the department, November 19, 1880, forty-eight years ago, to operate a coffee mill, was of this material. While the coffee mill has long since disappeared, the service is still operating at the same old stand in the busiest section of our city. Arguments have been brought to our department telling us of the advantages of other material, but we have tried out extra-strong lead pipe, know what it has done for us in the past and are willing to rest on its serviceability for the future. If extra-strong lead pipe is subject to electrolysis we have never been affected to a degree to cause alarm.

The final analysis of the service question brings me to the conclusion that a large portion of the troubles existing today in water departments is the result of over-sights in the past. It is commendable, of course, that efforts were made to reach out and give city water to consumers, but more consideration should have been given to the future than to the present and efficiency of a more lasting nature should have been one of the provisions.

MANGANESE IN THE WATER SUPPLIES OF NEW JERSEY

By Leroy Forman[1]

It has been known for some time that a few of the deep wells in the vicinity of Camden, New Jersey, contain traces of manganese and that manganese produces far greater annoyance in the household than iron. Only comparatively recently the Department of Health of the State of New Jersey has been cognizant that manganese is more or less prevalent in the surface waters of the state from which the larger cities obtain their drinking water supply and the hazard which its presence might mean in such supplies in securing a bacteriologically safe water where chlorination is relied upon as the disinfecting agent. Two of the largest municipalities in New Jersey obtain their drinking water supply from reservoirs supplied by streams from the mountainous regions in the northwestern part of the state and prolonged storage followed by chlorination is the method of treatment.

During the summer of 1928, in the regular examinations of all the public potable water supplies of New Jersey, which the Department of Health is periodically required to make by law, B. coli was found to be present in practically all of the five 10 cc. portions of the first sample submitted from one supply and in a subsequent sample that was requested to be collected to check the analysis of the former one. An investigation of the supply disclosed several interesting facts:

a. The bacteriologist in charge of the laboratory of the local water department had found B. coli on numerous occasions during the summer and then he would telephone to the chlorination station, a distance of 17 miles, to increase the chlorine although his residual chlorine test with orthotolidin would indicate 0.08 to 0.12 p.p.m. On other days when B. coli was not found in the delivered water, the instructions were to decrease the amount of chlorine added. This

[1] Senior Chemist, Bureau of Engineering, State Department of Health, Trenton, N. J.

raising and lowering of the chlorine dose continued alternately for several months.

b. At the time of the investigation, a residual chlorine test of 0.10 p.p.m. was obtained at the laboratory, which as stated above is 17 miles from the point of application and 4 miles from the municipality supplied with the water.

c. A visit to the chlorination station where a calculation of the amount of chlorine being added and the volume of water pumped showed that only 0.05 p.p.m. of chlorine was being applied, yet 0.10 p.p.m. was obtained at a point 17 miles distant With this discrepancy the logical procedure was to test the water at a point several hundred feet above the point of chlorination with orthotolidin. When this was done a color was produced equivalent to 0.08 p.p.m. of residual chlorine.

d. A large sample of the unchlorinated water was brought back to the laboratory of the State Department of Health where a chemical analysis detected the presence of manganese.

Tests were made upon distilled water, to which known amounts of manganese were added with orthotolidin reagent (A. P. H. A. solution) and manganic compounds produced a yellow color while the manganous compound produced no color. One tenth of 1 p.p.m. of manganese in the manganic form gave a color corresponding to 0.13 p.p.m. of residual chlorine. It was concluded that manganic compound would react with orthotolidin and having tested numerous surface waters used for public potable water supplies with the reagent and having found about 25 per cent of them to give a color reaction a note of warning was published in the *Public Health News* for October, 1928, a monthly publication of the Department of Health of the State of New Jersey, under the caption, "False Results by the Orthotolidin Test for Residual Chlorine." After calling attention to the experience mentioned above in this paper and while further experiments were being conducted, the following suggestion was made to all water purification plants using chlorine as a sterilizing agent:

> For the present it is suggested that all water purification plants using chlorine as a sterilizing agent make an orthotolidin test on the raw water or on the filtered water, if filtration is used, at least once a day. Should any color be obtained it is to be compensated for when making the residual chlorine test on the final water by subtracting the amount found in the raw or filtered water from that found in the final. The difference will represent the actual residual chlorine in the final water.

TABLE 1

Data on New Jersey water supplies

MUNICIPALITY	SOURCE OF SUPPLY	TREATMENT	NUMBER OF SAMPLES TESTED FOR MANGANESE	MANGANESE
				p.p.m.
Allentown	Surface	Coagulation, sedimentation, filtration and chlorination	2	0.05
Atlantic City	Wells and surface	Chlorination for surface	2	0.06
Avon	3 wells, 500 to 1,150 feet	Iron removal	2	0.05
Bay Head	4 wells, 700 to 900 feet	Chlorination	2	0.04
Blairstown	Well, 300 feet	None	3	0.03
Bogota	Well, 180 feet	None	2	0.06
Boonton	Surface	Chlorination	2	0.04
Branchville	Surface	Chlorination	2	0.08
Bridgeport	4 wells, 40 feet	None	4	0.04
Bridgeton (Co. Inst.)	Well	None	2	0.08
Brigantine City	Well, 829 feet	None	2	0.08
Brooklawn	2 wells, 152 to 165 feet	Chlorination	3	0.04
Burlington	Surface	Coagulation, sedimentation, filtration and chlorination	5	0.10*
Butler	Surface	Chlorination	3	0.06
Cape May City	6 wells, 290 to 312 feet	Chlorination	2	0.04
Carneys Point	3 wells, 78 feet	None	3	0.25
Clarksboro(Co. Inst.)	Spring	None	2	0.06
Columbus	2 wells, 230 feet	None	1	0.08
Dutch Neck	2 wells, 30 feet	None	2	0.04
Fortesque	Well, 300 feet	None	3	0.02
Grenloch (Realty Co.)	2 wells, 100 to 160 feet	None	3	0.04
Greystone Park	Surface	Chlorination	3	0.10
Haddon Heights	36 wells, 52 to 408 feet	None	3	0.04

TABLE 1—*Continued*

MUNICIPALITY	SOURCE OF SUPPLY	TREATMENT	NUMBER OF SAMPLES TESTED FOR MANGANESE	MANGANESE
				p.p.m.
Hamilton Square	Well, 130 feet	None	3	0.07
Helmetta	3 wells, 24 to 280 feet	Softening plant	1	0.10
Island Heights	4 wells, 50 to 300 feet	None	2	0.10
Jersey City	Surface	Chlorination	2	0.04
Lakehurst	Well, 125 feet	None	2	0.04
Lavallette	Well, 1,522 feet	None	2	0.10
Leesburg	Well	None	1	0.04
Lodi	5 wells, 305 to 320 feet	None	1	0.04
Lumberton	Well, 400 feet	Chlorination	1	0.04
Mays Landing, W.D.	3 wells, 250 feet	None	2	0.08
Milltown	Mixed	Chlorination for surface	3	0.03
New Egypt	Well, 238 feet	None	3	0.03
Ogdensburg	Surface	Chlorination	2	0.06
Oxford (Co. Inst.)	Spring	None	2	0.03
Pemberton	Surface	Chlorination	4	0.04
Penns Grove	8 wells, 55 to 180 feet	Iron removal	1	0.03
Phillipsburg (L. W. Co.)	Surface	Chlorination	3	0.04
Princeton Junction	Well, 98 feet	None	3	0.10
Rahway	Surface	Coagulation, sedimentation, filtration and chlorination	2	0.03
Sea Girt	3 wells, 760 feet	None	1	0.04
Seaside Heights	Well, 460 feet	None	3	0.16
Seaside Park	3 wells, 139 to 463 feet	Iron removal and chlorination	2	0.10
Ship Bottom	2 wells, 500 to 590 feet	None	2	0.04
Short Hills	14 wells, 60 to 328 feet	None	2	0.04
Stanhope	2 wells, 54 to 90 feet	None	1	0.03

TABLE 1—*Concluded*

MUNICIPALITY	SOURCE OF SUPPLY	TREATMENT	NUMBER OF SAMPLES TESTED FOR MANGANESE	MANGANESE
				p.p.m.
Surf City	Well, 564 feet	None	2	0.02
Sussex	Surface	Chlorination	2	0.08
Swedesboro	5 wells, 138 to 200 feet	Chlorination	2	0.18
Toms River	7 wells, 47 to 62 feet	None	3	0.12
Tuckerton	Well, 190 feet	None	2	0.20
Wenonah	8 wells, 210 to 250 feet	None	4	0.08
Woodbine	5 wells, 150 to 160 feet	None	1	0.04
Woodstown (Co. Inst.)	Dug well and collecting spring	None	1	0.06

* In one of the 5 samples.

In the meantime experiments were made to develop a quantitative colorimetric method using orthotolidin. The greatest difficulty encountered was the oxidation of all the manganese to a form which would produce a color with the orthotolidin reagent. The common oxidizing agents were either unsatisfactory or the length of time required for the complete oxidation too long for practical purposes. Finally the manganese was converted to the hydrate with sodium hydroxide and oxygen or air bubbled through the alkaline solution. If oxygen is used ten minutes is sufficient, but with air twenty to thirty minutes are necessary for the oxidation of all the manganese. The yellow color given by orthotolidin with oxidized manganese is the same shade as the permanent standards for residual chlorine made with potassium dichromate and copper sulphate as given in Standard Methods of Water Analysis, A. P. H. A., 1925. The intensity of the color as given with known amounts of manganese is slightly greater than with equivalent amounts of chlorine so that the observed readings on the permanent chlorine standards should be multiplied by 1.25 to obtain the quantity of manganese present.

The complete method that is given below will, in the writer's opin-

ion, easily and accurately determine 0.02 p.p.m. of manganese in water:

To 100 cc. of water in an Erlenmeyer flask add 5 to 6 drops or more if necessary, of a 1 per cent solution of sodium hydroxide; bubble oxygen (from a cylinder of the compressed gas) through the solution for ten minutes. (If oxygen is not available, air can be used but a longer period is necessary.) Transfer the liquid containing the oxidized manganese to a 100 cc. Nessler tube and add 5 cc. orthotolidin solution. Allow to stand fifteen to twenty minutes for the maximum development of the color. If iron is present in amounts of 0.5 p.p.m. or more, 5 cc. syrupy phosphoric acid is added before the orthotolidin solution. The color produced is compared with permanent standards made with known amounts of manganese or with the permanent standards for residual chlorine. If compared with the residual chlorine standards the readings observed are multiplied by 1.25.

Two hundred and thirty-eight of the two hundred and eighty-nine public potable water supplies of New Jersey have been tested by the above method at least once and in the majority of instances from two to five times during the past seven months and fifty-six of the supplies or 24 per cent of those tested, show the presence of manganese in the delivered water in amounts varying from 0.02 to 0.25 p.p.m.

Time has not permitted a study of the manganese content of all the raw surface waters or of the percent removal by filtrations, but one particular supply that has been tested indicates that approximately 98 per cent of the manganese was removed. The raw water contained approximately 2.0 p.p.m. of manganese. It is treated with alum and soda ash; after a moderate sedimentation period it is filtered through slow sand filters. The treated and filtered water contained only 0.04 p.p.m.

Table 1 gives the list of public potable water supplies in New Jersey that have shown the presence of manganese during the period from August 1, 1928, to March 1, 1929; also the source of each supply, treatment, if any, and number of samples tested.

REDUCTION OF CARBONATE HARDNESS BY LIME SOFTENING TO THE THEORETICAL LIMIT[1]

By Charles P. Hoover[2] and James M. Montgomery[3]

If lime would react quickly when added to hard water containing calcium bi-carbonate and magnesium compounds, and, as accepted equations represent that it should, then carbonate hardness could be easily reduced to the theoretical limit. Unfortunately, however, lime water softening reactions do not proceed in an orderly fashion as represented by the equations and the reduction of the carbonate hardness to the theoretical limit becomes a very important water softening problem and one that has been receiving attention, study and experimentation for the past 20 years.

Instead of calcium carbonate and magnesium hydroxide being precipitated as represented, soluble basic carbonate complexes of magnesium are produced which may possibly have the following formulae:

$$Mg_4(OH)_2(CO_3)_3$$
$$MgCO_3 \cdot NaHCO_3 \cdot 4H_2O, \text{ or}$$
$$MgCO_3 \cdot Na_2CO_3$$

These soluble salts cause the carbonate hardness of lime softened water to be higher than it theoretically should be. This is especially so when soda-ash and lime are used. When softening a hard magnesium water from Ohio wells, or from streams such as the Scioto and Miami Rivers, a 50 per cent average reduction of magnesium and an average reduction of carbonate hardness to 50 or 60 parts per million has been considered good unless special treatment processes were used.

These special processes with their advantages and disadvantages have been previously described.[4] They are: (1) The hot process;

[1] Presented before the Water Purification Division, the Toronto Convention, June 27, 1929.

[2] Chemist in Charge, Water Softening and Purification Works, Columbus, Ohio.

[3] Manager, Water Works, Piqua, Ohio.

[4] Industrial and Engineering Chemistry, 19: 5, May, 1927.

(2) Excess lime treatment; (3) Split treatment; (4) The use of compounds of alumina; and (5) Substitution of zeolite for soda-ash to remove non-carbonate hardness.

SOLUBILITY OF CALCIUM CARBONATE AND MAGNESIUM HYDROXIDE

The purpose of this paper is to describe a process by which the carbonate hardness can be reduced to the solubility limit of calcium carbonate and magnesium hydroxide.

Chemical handbooks usually record the solubility of calcium carbonate as being 13 to 20 parts per million and magnesium hydrate as being 1 part per million, or, in terms of calcium carbonate, 1.7 parts per million.

These figures represent the limit to which carbonate hardness can be reduced by lime softening. In actual practical use of this process, results as low as 17 parts per million, have been obtained.

THE EXCESS LIME RECARBONATION PROCESS

The process to be described has been in continuous use at Piqua since June, 1927, and has since been used at Columbus, Marion, Delaware, Greenville, Newark and other Ohio plants.

If lime is added in sufficient excess it will not only convert the bicarbonates to normal carbonates, but will precipitate practically all of the magnesium salts as magnesium hydroxide. The excess lime required to precipitate the magnesium compounds to the lowest possible limit has been found at Columbus and Piqua to be that amount necessary to give the water a caustic alkalinity of approximately 40 parts per million. The caustic alkalinity or excess lime being determined on samples of water taken at the outlets of the mixing tanks. Lime softening reactions may not be entirely completed upon leaving the mixing basins and as these reactions depend largely on the temperature, the sufficiency of the dosage is more accurately determined if the samples are heated to 50°C. and filtered through paper filters before the titration for excess lime is made. After heating and filtering the sample, a 100 cc. portion is titrated with N/50 sulphuric acid using phenolphthalein as an indicator. When the end point is reached, methyl orange indicator is added and the titration continued to the end point. Twice the alkalinity to phenolphthalein should exceed the methyl orange alkalinity by approximately 40.

The following is a typical analysis of water from the mixing tanks at Columbus and Piqua.

	p.p.m.
Total alkalinity	68
Phenolphthalein alkalinity	51
Caustic alkalinity	34

After the bulk of the precipitate has settled out, the water should be recarbonated. Montgomery[5] discovered that recarbonation should be continued to the point where the total alkalinity minus two times the phenolphthalein alkalinity equals approximately 5. For example:

	p.p.m.
Total alkalinity	53
Phenolphthalein alkalinity	24
Caustic alkalinity	0

If water softened and recarbonated as described is allowed a long reaction period as at the Marion, Ohio, plant or if it is filtered through conventional type sand filters the alkalinity will drop to about the solubility limit. Recarbonated water of the above analysis filtered through the Columbus filters showed the following results:

	p.p.m.
Total alkalinity	22
Phenol alkalinity	11
Caustic alkalinity	0

The average results (in p.p.m.) at Piqua in May, 1929, were as follows:

	RAW	OUTLET MIXING TANKS	RECARBONATED*	SETTLED	FILTERED
Methyl alkalinity	145	64	70	54	22
Phenol alkalinity	0	49	30	25	9
Caustic alkalinity	0	34	0	0	0
Total hardness	165	93	98	83	52
Magnesium	20				2

* Water recarbonated at outlet of Dorr Clarifier ahead of settling basins.

[5] Ohio Conference on Water Purification, 7th Annual Report.

THE ADVANTAGES OF THE PROCESS

1. Carbonate hardness can be reduced to practically the theoretical limits.
2. Consistent reduction in hardness can be made irrespective of temperature.
3. Cost of softening is reduced.
4. Carbon-dioxide content of softened water reduced, and
5. Removal of magnesium according to Graf[6] eliminates much of the scum left in pans and bath tubs by the reaction of the water with soap.

TABLE 1

Operating Results at Piqua, Ohio

RAW WATER		FILTERED WATER	
January 1, 1928. Water temperature 38°F.			
	p.p.m.		*p.p.m.*
Total alkalinity	119	Total alkalinity	22
Total hardness	145	Phenol alkalinity	9
Magnesium	15	Total hardness	54
		Magnesium	2
June 14, 1929. Water temperature 72°F.			
Total alkalinity	187	Total alkalinity	20
Total hardness	210	Phenol alkalinity	9
Magnesium	20	Total hardness	48
		Magnesium	2

EFFECT OF TEMPERATURE ON PROCESS

The reduction in carbonate hardness by this process is much less influenced by the temperature of the water, than by the conventional type softening process. Typical results obtained at Piqua, while treating cold river water in freezing weather and relatively warm river water in the summer time are shown in table 1.

COST OF THIS PROCESS OF REMOVING HARDNESS AS COMPARED WITH REMOVING IT WITH SODA-ASH OR BY ZEOLITE TREATMENT

During the 19 years of operation of the Columbus Plant before recarbonation, the alkalinity of the softened filtered water averaged

[6] Private communication.

55 p.p.m. with 5 p.p.m. of caustic alkalinity or excess lime. Very close supervision of operation is required to reduce the carbonate hardness to the theoretical solubility limit. It is not, however, especially difficult to control the process so as to reduce the carbonate hardness to say 30 p.p.m. At the Columbus plant the average carbonate hardness of the filtered water during the past three months has been 30 instead of 55 p.p.m. as a general average over 19 years. The difference between 55 and 30 p.p.m. is 25 parts per million. In other words the hardness removed because of the use of the process amounts to 25 p.p.m. To accomplish this 1.7 grains of additional lime are required, which equals 243 pounds per million gallons and at $6.71 per ton, amounts to 81 cents per million gallons. If this hardness were not removed by the use of this process, then to meet the standard of hardness maintained at the Columbus plant, it would be necessary to remove the equivalent of this hardness with soda-ash or by the use of zeolite. To remove 25 parts per million with soda-ash at $27.62 per ton, the cost per million gallons amounts to $3.14. The saving per day, indicated by these large scale operations at Columbus, is the difference between $3.14 and 81 cents multiplied by 30 million gallons per day or $69.90.

To remove 25 p.p.m. with zeolite 0.35 pound of salt per 1000 grains hardness removed and salt at $6.50 per ton, the cost per million gallons amounts to $1.67. In addition to the cost of salt there would also be some extra expense for wash water.

RECARBONATION PRACTICED AS OUTLINED DECREASES THE CO_2 CONTENT

The question is often asked: Will the addition of CO_2 gas required to recarbonate water increase its corrodibility? The answer is no, unless not applied as hereinbefore related. There is less carbon-dioxide in the water so softened than in uncarbonated softened water as previously softened at municipal water softening plants. That is of course not true where the excess lime and soda treatment is practiced as by railroads and industrial plants.

To explain why there is less free CO_2 in overtreated recarbonated water than in ordinary softened water without recarbonation, it is necessary to explain that CO_2 may exist in water in three forms: Free, half-bound and bound. For example: The average alkalinities of the filtered water at Columbus, for the past 19 years were as follows:

	p.p.m.
Total alkalinity	55
Phenolphthalein alkalinity	30
Caustic alkalinity	5

This water contained CO_2 as follows:

	p.p.m.
Free CO_2	0
Half-bound	0
Bound	22
Total	22

The softened recarbonated water at Columbus on March 24, 1929 using excess lime followed by recarbonation shows CO_2 as follows:

	p.p.m.
Free CO_2	0
Half-bound	0.9
Bound	10.1
Total	11.0

In other words the second analysis on recarbonated water shows only half as much CO_2 as the first analysis of water which was not recarbonated.

DISADVANTAGES OF PROCESS

Recarbonation was developed for the purpose of stabilizing lime softened water.

Filter sand incrustation, deposits in mains and meters in Columbus have already been described:[7]

The question now arises; Have the benefits of recarbonation as originally used been lost by using it as herein described?

In so far as the operation of the filters is concerned it has.

EFFECT OF THE PROCESS ON SAND FILTERS

As shown by the results given, from 25 to 30 parts per million of hardness are removed by being deposited on the filter sand. In time the sand grains will become incrusted just as they did formerly at water softening plants before recarbonation was developed. Judging from the rate of growth of the filter sand at Piqua, unless some means of removing the incrustation is employed, it would probably be necessary to replace the sand after about 10 years of operation.

[7] Industrial and Engineering Chemistry, Volume 19, July, 1927.

It is estimated, however, that, even if the sand has to be renewed in 10 years, it is still economical to use the process because the saving in softening chemicals will more than pay the cost of sand replacement.

Although the water incrusts the sand grains, the water leaving the filters is apparently stable. After two years of operation at Piqua, several taps were made in the water mains and no incrustation was visible. A number of meters were removed for examination and no deposits were found.

At Delaware, Ohio, where this process is being used and where there is already incrustation in the distribution system, a second dosage of carbon-dioxide is applied to the water after filtration. The purpose of this additional carbon-dioxide is to make the water sufficiently corrosive to dissolve some of the carbonate already in the mains.

SCHEMES BEING TRIED TO THROW THE BURDEN OFF THE FILTERS

Various methods of removing this burden from the filters are being tried. At Piqua the incrustation has been removed successfully by taking the filter out of service after two or three months use and then allowing the highly acid water from the carbonation scrubber to flow up through the sand and out through the wash water troughs. After two or three weeks of this treatment the incrustation has been dissolved and the filter is again ready for service.

The calcium carbonate formed by the recarbonation in this method of treatment will crystallize out and settle if sufficient settling time is provided. Tests to determine the minimum time are now being made.

Experimental results indicate that the reaction will go to completion much more rapidly if the softened water is agitated after being recarbonated.

Return of sludge, the addition of coagulating materials and filtration through coarse filtering materials are some other schemes that are receiving attention.

THE PRESENT AND FUTURE OF THE ERIE WATER DEPARTMENT[1]

By J. S. Dunwoody[2]

The City of Erie, Pennsylvania, located on the shores of Lake Erie midway between Buffalo and Cleveland, covers an area of 20.5 square miles and has a population of 130,000. Its water supply is taken from Lake Erie, an unlimited source.

The control of the Erie Water Department is vested in a board of three, known as the Commissioners of Water Works in the City of Erie. These Commissioners are appointed by the Judges of the Court of Common Pleas of Erie County, and their appointment is for a period of three years. One reappointment is usually accorded each Commissioner, giving him at least 6 years to serve in this capacity.

The law creating the Erie Water Department and its method of control is a special act of the State Assembly of 1867, the date of the beginning of the first municipal water works at Erie. The original bill still forms the basis of control and operation.

In giving this description of the Erie Water Department I would like to have you picture it as a business having fixed assets of 5⅓ millions, with an annual revenue of over $600,000.

DESCRIPTION OF SYSTEM

In describing the present system we will endeavor to follow the course of the water from its source to its delivery to the consumer.

The intake crib, located 1 mile in the lake, and 17,641 feet from the low duty suction well, is constructed of wood. It is 40 feet square and 19 feet high, is completely submerged, and at normal stage of water carries 22 feet of water over the grating. It is constructed as a unit subdivided into nine 12 feet by 12 feet compartments. The four corner pockets are built solid and are used for stone to hold the crib in place. The other five compartments are

[1] Presented before the Central States Section meeting, August 23, 1928.

[2] Superintendent, Water Works, Erie, Pa.

used as water ways and are constructed on the inside walls and top of timber in the form of grating.

The intake, starting at the crib, is a 60-inch tee pointing up into the center pocket. The outer end of the tee is bulkheaded off so as to permit only a down draught of water, thus preventing sand or other fine material from entering the intake. The intake pipe, starting from the crib tee, is 60 inches in diameter and is laid following the contour of the lake bottom to the raw water well at the pumping station, a distance of 17,641 feet. Riveted steel is used for 9334 feet of the intake and the balance is of cast iron. The 8307 feet of cast iron pipe represents the first section of this intake to be laid, and produced the water supply for the city from 1896 to 1908 from Presque Isle Bay or Erie Harbor. Serious pollution of the harbor water forced the extention of the intake to the lake in 1908.

Erie Harbor is formed by a natural peninsula projecting into Lake Erie. The bay formed by this peninsula is 5 miles long by 2 miles wide, open at one end by a ship channel which forms the greatest natural ship harbor on the Great Lakes. This peninsula is now owned and controlled by the Pennsylvania State Park and Harbor Commission, and is fast developing into one of the greatest natural state parks. The Water Commission of Erie owns 175 acres on this peninsula or a sufficient area to give them control of that portion where the intake crosses. In addition to the intake the Water Commission has constructed on Presque Isle Peninsula a natural settling basin, and has provided an emergency intake connection. This emergency intake is for the collection of harbor water should a failure of the lake intake occur.

The settling basin is directly connected to the intake and provides 24 hours of natural settling for the supply as a pre-treatment to filtration. Its use reduces to a minimum the quantity of coagulant required at the filtration plant.

From the raw water well at the pumping station the water is pumped to the filtration plant where the normal processes of mechanical filtration are carried out. The filter plant has a rated capacity of 32 m.g. per day (on the basis of 125 million gallons per day per acre), and is capable of carrying a 50 per cent overload with safety. Aluminum sulphate is used for the coagulant, the average dose being 0.2 of a grain per gallon. The dose range is from 0.1 to 0.4 of a grain, depending on the turbidity. Master and individual controls regulate the plant operation. About 97 per cent bacterial efficiency is

obtained on the filters, and this is increased to better than 99 per cent by the application of calcium hypochlorite solution having a chlorine value of 1 pound per million gallons treated.

Filtration costs for the year 1927 were $59,700 for the treatment of 8,792,000,000 gallons of water or $6.79 per m.g. This figure includes operation, maintenance and depreciation.

The clear wells at the filtration plant form the suction wells for the low service pumping units. The low service, or Chestnut Street, pumping station, delivers the entire supply of the city to the low service district and reservoir, against a total operating head of 258 feet. The interesting feature of this station is that each of its four pumping units is of a distinctively different type. The oldest unit is a horizontal cross compound steam engine of 8 million capacity placed in service in 1899. Next is a triple expansion vertical steam engine of 20 millions capacity erected in 1913. In 1917, a 20 million gallon steam turbine driven centrifugal, and in December, 1925 a 12 million gallon motor driven centrifugal pump were placed in operation. The installation of a motor driven unit in a steam plant which had ample boiler capacity to operate additional units might call for inquiry in the minds of some, but with current costing less than $0.01 per kilowatt hour, we delivered in 1927, with this electric unit 170,799,200 foot pounds per dollar of cost, while with steam we were able to deliver only 140,902,300. In addition to the above we were desirous of experimenting on this method of pumping against high heads, so as to be informed on probable future installations.

It is my opinion that electrically actuated pumping units will be given increasing consideration, especially where power can be purchased at $0.01 per kilowatt hour or less.

The second or high service district is supplied from the high service pumping station at 26th and Sigsbee Streets. This station takes its suction from the low service reservoir and delivers to the high service district and reservoir against an operating head of 98 feet. This station has been in operation since December, 1927, is fully electric with automatic control as to stopping and starting. Prior to this station being built both the high and low districts were served from the Chestnut Street station. An interesting fact in connection with the separation of the two services is that the over-all cost of delivery to these two districts has been reduced by nearly $2.00 per m.g., over and above the full cost of operation, maintenance and depreciation on the new plant. A much more reliable supply has also been established, which cannot be estimated in dollars and cents.

A third or booster service station takes suction from the high service reservoir and delivers to an elevated water tower against an operating head of 144 feet. This is a small residential district with a consumption of from 60 to 75 thousand gallons per day. This station is electrically operated and automatically controlled.

Pumpage costs to these three districts, including operation, maintenance and depreciation, are as follows; using the figures for July, 1928 as representative.

	Daily demand	*Dollars per million gallons*
Low service	19,624,600	11.44
High service	6,137,300	10.11
Total		21.55
Booster service	93,100	71.63
		93.18

While we are on the subject of pumpage it might be well to discuss at this time our demands. The total pumpage for 1927 was 8,792,000,000 gallons or a daily per capita of 193, a figure much too high, and indicating a system waste of some kind. This waste is known to the department and is one that no doubt several of you have experienced, i.e., flat rates to domestic consumers. The Erie supply is metered only on the industrial services, there being no established rate for the domestic sale of water. This is a subject which has given the local department much concern, and is the key to the course that must be followed in the immediate future. Since 1918, there has been an endeavor to establish a rate which would justify universal metering, but to date we have not succeeded in having such a rate approved.

Unless steps are taken immediately to reduce the demands on our present equipment, the proposed new plant, which I am to describe in this paper, cannot be built in time to avoid a water shortage should a protracted dry spell create a peak greater than we are meeting at the present time.

To complete the picture of our present system before attempting to describe our proposed plant, I should mention the distribution system. We are using over 330 miles of mains, all of cast iron, and varying in size from 4 to 42 inches in diameter. While there are about 25 miles of 4-inch main in our system, this size is no longer being

installed where fire protection is demanded on the system. The main layout is of the grid type and is carried out in the newly developed areas as completely as is practical. Thirty-five hundred valves of various sizes are installed in this net work of pipe, which also includes 1350 fire hydrants.

Twenty-five thousand services are in active use, with sizes varying from $\frac{3}{4}$- to 12-inch.

I have already told you of our per capita demand, and also what was the answer to these excessive requirements in 1918 to 1920. Because of our failure to obtain relief through universal metering, we have now reached the point where a completely new plant, built without further delay, is the only means of meeting the rapid growing demands.

PLANS FOR NEW PLANT

The intake previously described has a theoretical capacity under ideal operating conditions of 40,000,000 gallons per day. The actual delivery is but 36,000,000 gallons per day, which is the present peak load under normal summer weather conditions. A long period of dry warm weather would cause a demand beyond our intake capacity. Seeing the rapid approach of such a condition the department was fortunate in being able to purchase a piece of land, approximately 20 acres, well located for a water works plant, just outside of the city limits and within short distance of a large feeder main.

Preliminary plans for this new station and intake are being developed at the present time by The J. N. Chester Engineers, but unfortunately are not far enough along for me to show any of the details.

The new station will be about 3 miles from our present location. This will assure a more constant pressure throughout the distribution system by reducing the velocity losses and eliminating the immediate need of additional carrying mains.

The location of the proposed plant will permit us to locate our intake crib in as deep water as our present one with considerably less than half the length of intake. If we can shorten our intake 9,000 feet, estimating its cost at $50.00 per foot, a saving of about $450,000 can be made over attempting to parallel our present pipe for increased volume.

The ground contour at Erie is such that an immediate rise of from 30 to 40 feet takes place as soon as you leave the shore of the harbor.

The new layout will permit the construction of the filter plant and pumping station on the bank overlooking the harbor, thus reducing the head on the pumping equipment correspondingly. This benefit will be offset somewhat by the increased head on the low duty pumps. However, there is a distinct advantage in the proposed scheme.

The intake will not follow the contour of the lake and harbor bottom, but will have a continuous fall from the raw water well to the crib. This will eliminate all high points other than the one at the well, which can be easily controlled. The pumping will be done by electrically actuated pumps, thus eliminating the necessity for a boiler plant and its many accessories. It will require such a small area that it will be possible to incorporate the filter plant and pumping station into one building. The initial cost of pumping equipment will be reduced several hundred per cent.

Last but not least the operating labor with a combined filter plant and pumping station will be reduced to at least one third of the requirements of a steam operated station.

The construction of this new plant will be so arranged that it can be carried on by units. The intake will of course be completed at the time of building the first unit, and will probably be 72 inches in diameter and approximately 8000 feet in length.

The low duty pump house will be ample to house the maximum capacity of the plant, with one-third of the equipment being installed first. The normal maximum will be 48 millions per day and the first construction will be for one third of that amount or 16 million, with ample coagulation basins for 32 million on the basis of $3\frac{1}{2}$ hours time.

The pumping units are to be of convenient sizes to meet the demand, and of sufficient total capacity to give an ample number of reserve units.

The force mains will be arranged in pairs and it is our desire to limit the size after leaving the station to not over 24 inches in diameter.

I regret that the preliminary work on this project has not been sufficiently developed to give you a more conclusive picture of this project together with some accurate figures. A rough estimate of the cost of the project as outlined above is $1,500,000.

George C. Gensheimer

Born October 30, 1859, died June 28, 1929

The death of George C. Gensheimer came as a shock to all who knew him and conveyed the sense of a great personal loss.

It comes to comparatively few men to serve as he did for half a century so faithfully in the same organization engaged in the oldest and most useful of all public utilities, that of operating a public water supply.

The City of Erie, Pennsylvania, where he lived and labored so many years will long hold in memory his ability and his usefulness. The members of the American Water Works Association in which he had held a high office will not soon forget his unselfish and untiring work for this society or the genial, kindly, gracious manner which seemed always to accompany and be instinctively a part of him.

When his associates in the Erie Water Department at our convention in Toronto told of the sudden and serious attack of pneumonia which had seized him, there was held out hopes for his recovery, but almost at the same hour at which our 49th annual convention adjourned his death occurred.

To his family, the officers and members of the American Water Works Association extend deep sympathy and at this time desire to record here the loss of a great and true friend of the Association. As a member he was always enthusiastic and loyal and as Treasurer of the Association for the past three years he was faithful and efficient.

Beekman C. Little.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Lansing Owns and Installs All Water Meters. L. E. HACKETT. American City, **40**: 6, 85–90, June, 1929. There are 18,000 water meters in the city of Lansing, Mich., installed on 21,500 water services. Almost all meters installed at present are placed inside the building; if necessary to install on the outside, meter boxes following city specifications are utilized. All meters are owned, installed, and maintained by the Board of Water and Light Commissioners. The article gives a detailed account of the various record blanks and forms utilized by the city, which it is impossible to abstract adequately. It is interesting to note that the efficient meter department of the city enables 80 per cent of the water to be accounted for. In order that large capacity may be provided without utilization of costly large meters, a compound valve has been developed by the author permitting the use of two smaller meters. This valve causes two meters to run accurately in parallel.—*Chas. R. Cox.*

Developing the New Water-Works for Nassau, Bahama Islands. A. L. B. PLUNKETT. American City, **40**: 6, 101–4, June, 1929. A very rapid growth in the population of the city of Nassau, on the Bahama Island of New Providence, has necessitated the abandonment of inadequate wells and rain water cisterns which have been used heretofore as sources of water supply and the construction of a modern water supply system. A series of drilled wells were constructed in the so-called Blue Hills Range. In all, 65 wells are utilized, a group of 15 being 25 to 40 feet deep whereas the remaining 50 are very shallow as fresh water is encountered near the surface. The deeper wells are pumped by individual centrifugal pumps driven by 1 horsepower electric motors, whereas the shallow wells are pumped by air lift equipment. The well water is forced to open reservoirs and softened by lime soda softeners of English design. Presumably filters are not utilized to filter the softened water as they are not mentioned in the article. The softened water is chlorinated by Patterson chlorinators and is then forced by high lift pumps to the distribution system, the surplus going to a water tower.—*Chas. R. Cox.*

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[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

How Los Angeles Keeps Its Water Pure. H. A. VAN NORMAN. American City, **40**: 6, 117–9, June, 1929. The Los Angeles River, the original source of the water supply, was overtaxed some years ago after serving the city for 150 years. At present about 40 square miles of the municipality are supplied from the river and the remaining 400 square miles receive their water by aqueduct from the Owen Valley source. The Los Angeles River supply is secured from a number of wells, or infiltration galleries, which provide natural filtration of the water. Water from the aqueduct discharges into twenty-eight storage reservoirs along its route and at its terminus. The reservoir sites near the city are surrounded by manproof fences to prevent trespassing and concrete diversion walls are utilized at certain points to bypass the storm water from nearby hillsides. About 24,000 samples of water are examined in the laboratory of the water department each year. Results of these tests indicate that the waters are substantially free from organisms of the colon group. As an additional safeguard, the water is chlorinated with solution feed machines which receive their water supply from a series of electrically driven automatic pumps. In case the current to the motor of the pump in service fails, a gasoline-engine-driven pump is automatically started and kept going until an attendant can start the other electrically driven pump which is in reserve. Certain of the reservoirs are covered to prevent algae growth and at present a seven acre reservoir is being enclosed at a cost of $120,000.—*Chas. R. Cox.*

Existing Asset Recognized and Water-Works Rejuvenated. HENRY W. TAYLOR. American City, **40**: 6, 137–9, June, 1929. The City of Mechanicville, N. Y., has just completed water works improvements which have extended over a number of years. Essentially these improvements consist of the construction of reservoirs, pipe lines, and pumping stations.—*Chas. R. Cox.*

A Survey of Water-Meter Rates in the United States. Part I. American City, **40**: 6, 155–8, June, 1929. A tabulation of water meter rates from Section 9 of the 1929 Municipal Index which is a portion of the water supply statistics of American municipalities. It is impossible to abstract this tabulation.—*Chas. R. Cox.*

A Method for the Detection and Determination of Small Quantities of Manganese in Water. R. SCHMIDT. Chem.-Ztg., **51**: 1015–6, 1927. From Chem. Abst., **22**: 1202, April 10, 1928. Method of KOLTHOFF (C.A. **20**: 2380) was applied to determination of small quantities of manganese in water. Method consists in acidifying 100 cc. of water with 3 cc. 3N hydrochloric acid, drawing air through solution to remove carbonic acid, making alkaline with small excess of sodium hydroxide, drawing air through again, then adding 2 drops of 2 per cent aqueous solution of dimethyl-*p*-phenylene-diamine-hydrochloride. Finally a 10 per cent solution of citric acid is added dropwise until color appears, then 3 drops in excess. Reddish violet color is compared with standard. Ferric iron and nitrites interfere. Former is removed by formation of complex salt with citric acid, while 2 drops of 5 per cent sodium azide is sufficient to destroy nitrite. Test is not applicable to waters containing in excess of 50

p.p.m. manganese. Sensitiveness of test is 0.04 p.p.m. Determination requires about 15 minutes to carry out.—*R. E. Thompson.*

Pollution of Water Courses. M. BORNAND. Mitt. Lebensm. Hyg. **18:** 313–26, 1927. From Chem. Abst., **22:** 1202, April 10, 1928. Death of fish may be caused by sewage pollution, by industrial wastes, or by substances deliberately introduced for the purpose. Careful study of all conditions will usually fix cause. Calcium hypochlorite is most commonly used in deliberate poisoning of fish. Other poisons such as lime, calcium carbide, nux vomica, etc., are used less commonly.—*R. E. Thompson.*

A New Meter for Coal Used by Chain Grates. WINKELMAN. Wärme & Kälte Tech., **28:** 233–5, 1926. From Chem. Abst., **22:** 1226, April 10, 1928. Counter is actuated by movement of grate. Amount indicated by given distance of travel is regulated by setting of plate regulating depth of fuel on grate.—*R. E. Thompson.*

The Catalytic Properties of Mineral Water. II. The Benzidine Reaction, Investigated at the Wiesbaden Hot Springs. L. FRESENIUS and H. LEDERER. Z. anorg. allgem. Chem., **166:** 99–109, 1927. From Chem. Abst., **22:** 1201, April 10, 1928. Cf. C.A., **21:** 2039. All fresh water investigated gave positive benzidine reactions which, however, decreased as age of water increased. Decrease and disappearance of benzidine reaction parallels disappearance of ferrous iron.—*R. E. Thompson.*

The "Activity" of Known Ferruginous Springs. A. SIMON, K. KÖTSCHAU and G. BUSS. Z. anorg. allgem. Chem., **168:** 129–44, 1927. From Chem. Abst., **22:** 1202, April 10, 1928. So-called "active springs" act toward benzidine or guaiac resin in exactly same way as does ferrous bicarbonate. The "iron activity" is due to ferrous ion. Term "activity" is misleading. Loss of activity is connected with disappearance of ferrous ions, usually by oxidation.—*R. E. Thompson.*

Diurnal Variation of the Gaseous Constituents of River Waters. II. R. W. Butcher E. T. K. Pentelow and J. W. A. Woodley. Biochem. J., **21:** 1423–35, 1927. From Chem. Abst., **22:** 1202, April 10, 1928. Oxygen, nitrogen, pH, and temperature curves are given and discussed, as well as vegetation of rivers. Original must be consulted.—*R. E. Thompson.*

Water Treatment. KNIESEL. Gas- u. Wasserfach, **71:** 4–8, 1928. From Chem. Abst., **22:** 1201, April 10, 1928. Filter operation and cleaning are discussed. Allowing water containing excess carbon dioxide to flow over marble does not remove enough carbon dioxide. Installations for removing manganese should be of closed type.—*R. E. Thompson.*

Advances in the Preparation of Boiler Water in the Years 1925–1927. KARL HOFER. Chem.-Ztg., **52:** 11, Fortschrittsber., 1928, 10–18. From Chem. Abst., **22:** 1201, April 10, 1928.—*R. E. Thompson.*

Heat Transmission Through Boiler Tubes. H. O. CRAFT. Univ. Ill. Eng. Expt. Sta. Bull. **168**: 55 pp., 1927. From Chem. Abst., **22**: 1199, April 10, 1928. Results of experimental work carried out with apparatus designed to duplicate as closely as possible conditions existing in water-tube boiler.—*R. E. Thompson.*

Economy in Steam Raising. R. WIGGINTON. Trans. Inst. Min. Eng., **70**: 274–84, 1926; Fuel in Science and Practice, **7**: 71–4, 1928. From Chem. Abst., **22**: 1227, April 10, 1928. Various methods of promoting fuel economy in small boiler plants, where elaborate and expensive methods are impracticable, are discussed.—*R. E. Thompson.*

Effect of Stratification of Furnace Gases on Steam Boiler Losses. F. W. MARQUIS, PAUL BUCHER and H. M. FAUST. Ohio State Univ. Studies, Eng. Series, Bull. **34**: 82 pp., 1927. From Chem. Abst., **22**: 1228, April 10, 1928. Stratification of furnace gases, which causes marked lowering of efficiency, is evidently caused by faulty design and can be corrected only by change in furnace construction.—*R. E. Thompson.*

Water Treatment by Means of Colloids. A. T. RIDOUT. J. Inst. Brewing, **33**: 542–5, 1927. From Chem. Abst., **22**: 1201, April 10, 1928. Linseed extracted in a "Filtrator," an apparatus similar to an autoclave, is claimed to give colloidal infusion, which, added to boiler feed water at rate of 1 pound linseed per 2000 gallons of water, will eliminate scale formation. It effectively deals with oil in water, can be used with salt water feed, will not give bare boiler plates, and will not contaminate the steam.—*R. E. Thompson.*

Soap and Hard Water in Silk Manufacture. PROCTOR and GAMBLE. Can. Textile J., **44**: 869–71, 1927. From Chem. Abst., **22**: 1241, April 10, 1928. Effects and remedies.—*R. E. Thompson.*

Chemical and Physicochemical Purification of Industrial Waters. LANGUMIER. Arts et métiers, No. 87, 458–67, December, 1927; cf. C.A., **22**: 470. From Chem. Abst., **22**: 1201, April 10, 1928. Discussion of methods of purification. De-oiling of steam and water dealt with.—*R. E. Thompson.*

Modern Design of Carbon Dioxide Recorders and Indicators. A. GROUNDS. Fuel. Econ., **2**: 233–5, 1927. From Chem. Abst., **22**: 1254, April 20, 1928. Brief account given of 3 modern types of carbon dioxide recorders, the Cambridge Instrument Company's (cf. Engineering, **119**: 53, 1925), the "Ranarex" (cf. Power User, 1922, 302), and the "Union" (cf. Brit. pat. 148, 764; Ger. pat. 393,442), to illustrate improvement in design due to utilizing physical properties of gases in such instruments.—*R. E. Thompson.*

The Determination of Gases Dissolved in Water. H. RICHTER. Chem.-Ztg., **52**: 47, 1928. From Chem. Abst., **22**: 1296, April 20, 1928. In sampling water from boilers it is necessary to take precautions or all the gas will escape when pressure is removed. Thus when water at 138° and pressure of 45 atmos-

pheres was allowed to enter collecting bottle, no trace of oxygen or carbon dioxide was found unless water was first passed through a condenser.—*R. E. Thompson.*

Reaction of Sodium Alizarinmonosulfonate with Aluminium Under Different Experimental Conditions with Reference to Its Use in Colorimetry. J. H. Yoe and W. L. Hill. J. Am. Chem. Soc., **50**: 748–55, 1928. From Chem. Abst., **22**: 1296, April 20, 1928. With aluminium in alkaline solution sodium alizarinmonosulfonate forms red lake which is fairly stable in presence of acetic acid. Study was made of effects of time, temperature, volume, concentration of reagents, and presence of other ions. To carry out test, treat neutral solution with 5 cc. N hydrochloric acid, add 5 cc. 0.1 per cent Alizarin S solution and sufficient water to make 30 cc. Add 2 cc. of 5 N ammonium hydroxide with gentle stirring and after five minutes 5 cc. of 5 N acetic acid. Dilute to 50 cc., mix, and allow to stand in Nessler tube two minutes before making comparison of color. Temperature effect is very slight. Test is applicable to quantities of aluminum between 0.0004 and 0.2 mgm. Absence of iron and manganese is necessary.—*R. E. Thompson.*

Volumetric Determination of Chloride. Wm. B. Meldrum and J. C. Forbes. J. Chem. Education, **5**: 205–7, 1928. From Chem. Abst., **22**: 1297, April 20, 1928. Good results can be obtained with beginners using Mohr's titration method slightly modified. Make solution just acid to methyl orange with nitric acid and add enough 1 per cent sodium bicarbonate to turn indicator yellow again. As indicator for excess, use 5 drops molal potassium chromate solution and titrate with silver nitrate to faint red end point. Then boil five minutes, cool in ice water and finish titration. In this way a permanent end point is easily obtained.—*R. E. Thompson.*

Standardization of Silver Nitrate Solutions Used in Chemical Studies of Sea Water. T. G. Thompson. J. Am. Chem. Soc., **50**: 681–5, 1928. From Chem. Abst., **22**: 1296, April 20, 1928. Sodium chloride may be used to advantage for standardizing silver nitrate solutions.—*R. E. Thompson.*

Determination of Sulfate Ion as Barium Sulfate. V. Marjanovic. Arhiv. Hemiju, **1**: 5–18, 1927. From Chem. Abst., **22**: 1298, April 20, 1928. The solution, which should contain not more than 0.3 gram of sulfate, is evaporated to dryness; 5 cc. 10 per cent hydrochloric acid and 2 cc. saturated barium chloride are added to residue together with 100 cc. boiling water, and the whole is placed on water bath for 1 hour. Supernatant liquid is then decanted through Gooch crucible and precipitate treated with 1 cc. concentrated hydrochloric acid and 50 cc. cold water, and warmed on water bath for ten minutes, after which precipitate is filtered off through same Gooch crucible, washed, dried, and weighed. Average experimental error is 0.04 per cent for solutions of pure sulfates. Presence of chlorides and nitrates, and of sodium, potassium, magnesium, iron, copper, aluminum, and ammonium ions does not affect accuracy. Phosphate ions lead to high values, while in presence of calcium low results are obtained.—*R. E. Thompson.*

Use of Oxygen in Determination of Calcium and Magnesium. R. CERNATESCO and (Mlle.) E. VĂSCAUTAN. Ann. sci. univ. Jassy, **14**: 305–7, 1927. From Chem. Abst., **22**: 1298, April 20, 1928. When calcium is precipitated as oxalate and weighed as oxide, and when magnesium is weighed as pyrophosphate, the time taken by ignited precipitate to attain constant weight is much reduced if heating is carried out in current of oxygen.—*R. E. Thompson.*

Results of Tests Upon Cast Iron Pipe (French and American). A. BELESTRE. Rev. fonderie moderne, **21**: 86–8, 1927. From Chem. Abst., **22**: 1310, April 20, 1928. Comparison is made of typical French and American products tested by United States Bureau of Standards. Former were distinctly higher in phosphorus and silicon and lower in combined carbon. Minor physical differences were found. Practical values were similar.—*R. E. Thompson.*

Flaws Found in Cast Pipe Fittings. E. DECHERF. Rev. fonderie moderne, **21**: 132–3, 1927. From Chem. Abst., **22**: 1310, April 20, 1928. Photomicrographs (2) show weaknesses in mechanical condition due to crystal structure.—*R. E. Thompson.*

Corrosion of Metals. C. E. MACQUIGG. Bull. Compressed Gas Mfrs. Assocn. Tech. Series 1928, 321–3. From Chem. Abst., **22**: 1318, April 20, 1928. Short review of electrolytic theory of corrosion and of methods of protection.—*R. E. Thompson.*

The Practical Problems of Corrosion. II. Study of Protective Coatings. U. R. EVANS and R. T. M. HAINES. J. Soc. Chem. Ind., **46**: 363–7T, 1927; cf. C.A., **22**: 53. From Chem. Abst., **22**: 1318, April 20, 1928. Coatings of conducting and non-conducting materials discussed, and advantages of non-conducting coatings pointed out. Experiments with various coatings having scratches exposing the metal were made. Corrosion at scratches depended upon size of exposed area, nature of corroding medium, and nature of paint. Surfaces for painting should be free from rust and scale, and be absolutely dry. —*R. E. Thompson.*

Corrosion of Gas Pipes. Gas World, **88**: 105, 1928. From Chem. Abst., **22**: 1318, April 20, 1928. Summary of influences of various factors, from tests by OTT and HINDEN.—*R. E. Thompson.*

Iodine Content of Some Rocks and Its Relation to the Chemical Part of the Goiter Problem. E. WILKE-DÖRFURT. Ann., **453**: 298–315, 1927; cf. VON FELLENBERG, C. A., **19**: 1466. From Chem. Abst., **22**: 1385, April 20, 1928. Data given on iodine content of some rocks. Many natural phosphorites contain much larger quantities of iodine than do most other minerals. Relation between goiter incidence and geology of district may therefore be rendered complex by local use of phosphorites as fertilizers, and by passage of iodine into air when coal is burned.—*R. E. Thompson.*

Iodine Deficiency in Water as an Index of Goiter. D. F. SMILEY. Am. J. Hyg., **8**: 297–8, 1928. From Chem. Abst., **22**: 1419, April 20, 1928. Iodine content of water of a region is not an accurate index of frequency with which thyroid enlargement is to be expected in college students who come from that region.—*R. E. Thompson.*

Detection of Iodine in Drinking Water. PAUL DRAWE. Chem.-Ztg., **52**: 122–3, 1928, From Chem. Abst., **22**: 1419, April 20, 1928. The water acidified with nitric acid is treated with silver nitrate and filtered. The silver chloride is removed by extraction with ammonium hydroxide and residue treated with zinc and dilute sulfuric acid. Resulting solution is treated with chloramine; a blue color indicates presence of iodine.—*R. E. Thompson.*

The Purification of Water (With Special Reference to the Neckar Process). A. BATTIGE. Apparatebau, **40**: 25–7, 1928. From Chem. Abst., **22**: 1419, April 20, 1928. Various processes mentioned. In Neckar process the water is treated with soda, or soda and lime, filtered, and any sediment in boiler withdrawn continuously.—*R. E. Thompson.*

Priming and Impurities in Feed Water. A. W. EWELL. Power, **67**: 370–2, 1928. From Chem. Abst., **22**: 1420, April 20, 1928. Priming is increased by presence of sugar, alkalies, and acids and decreased by suspended particles of boiler scale or kaolin.—*R. E. Thompson.*

Decentralizing Rural Water Supplies. D. F. WORGER. Munic. Eng. Sanit. Record, **80**: 599–600, 1927. From Chem. Abst., **22**: 1420, April 20, 1928. Princes Risborough, England, is cited as successful example in experimental use of "Bruston" patent autopneumatic water supply system for villages or rural groups having population under 6000. Engines or motors operate usual pumps and deliver water into sealed cylindrical tanks, which are situated on discharge pipes from pumps to water mains. System does not require reservoirs or many of other usual details, and needs only minimum capital for outlay and maintenance.—*R. E. Thompson.*

Water Treatment at Gasoline Plants. F. B. GOOD. Oil & Gas J., **26**: 31, 97–113, 1927. From Chem. Abst., **22**: 1420, April 20, 1928. Various methods of treating water for engine cooling are briefly described. Tests used to identify various scales given together with methods of calculation.—*R. E. Thompson.*

Studying Corroding Action of Soils. H. D. HOLLER. Oil & Gas J., **26**: No. 32, 45, 187–8, 193, 1927. From Chem. Abst., **22**: 1426, April 20, 1928. Method of testing corrosive tendencies of soils is described in which hydrogen liberated from pulverized soil-iron mixtures is measured.—*R. E. Thompson.*

Lime. Report of Committee C-7. H. C. BERRY, *et al.* Proc. Am. Soc. Testing Materials, **27**: Pt. I, 324–9, 1927. From Chem. Abst., **22**: 1443, April 20, 1928. Several tentative specifications have been made standard. New

method for determination of mechanical moisture, and alternative method for determination of carbon dioxide are outlined.—*R. E. Thompson.*

The Determination of Iron in Glass Sand. G. E. F. LUNDELL and H. B. KNOWLES. J. Am. Geram. Soc., 11: 119–25, 1928. From Chem. Abst., 22: 1449, April 20, 1928. Electrometric titration, hydrogen sufilde reduction, and gravimetric methods described.—*R. E. Thompson.*

The Efficiency of Fuels. Food Manuf., 2: 215–6, 267–9, 261, 1927–8. From Chem. Abst., 22: 1456, April 20, 1928. Factors contributing to efficient use of fuels in boiler practice are discussed and detailed survey of sources of loss given: influence of ash, moisture in coal, size of coal, air supply, and frequency of firing; and losses on account of smoke, carbon dioxide, and excess air.—*R. E. Thompson.*

Combustion Control Formulas. III. Development of Heat-Loss Equations. E. A. UEHLING. Power, 66: 1010–2, 1927; cf. C.A., 22: 492. From Chem. Abst., 22: 1458, April 20, 1928. Equations developed. **IV. Applications of Formulas to Test Data.** Ibid., 67: 12–4, 1928. Above formulas given practical application. **V. Simplifying the Heat-Loss Formulas.** Ibid., 94–6. Formulas rearranged and somewhat simplified. **VI. Analysis of Heat Loss in Flue Gas.** Ibid., 135–8. Controllable heat loss divided into two parts, one chargeable to fireman and one to boiler cleaner. **VII. Fuel and Operating Efficiencies.** Ibid., 194–6. Results of preceding paper recalculated to percentage basis. **VIII, A Wage Bonus System.** Ibid., 242–4. Analysis of heat-loss components given in two preceding sections is used to develop equitable wage bonus system. **IX. Methods of Controlling Boiler Operation.** Ibid., 322–5. Analytic method of controlling boiler operation is compared with mechanical method, based on weight of water evaporated per weight of fuel used, and with synthetic method, based on unified steam-flow and air-flow records. Analytic method, based on analysis of heat losses and separation of avoidable from unavoidable heat losses, is considered most reliable.—*R. E. Thompson.*

Water-Cooled Furnaces. H. W. LEITCH. Combustion, 17: 89–93, 1927. From Chem. Abst., 22: 1500, May 10, 1928. Illustrated paper describing various installations of water-cooled furnaces, together with results. Principal advantages of water-cooled walls are high boiler ratings, higher rates of combustion, lower excess air and elimination of refractory maintenance.—*R. E. Thompson.*

Boilers with Water Walls for Industrial and Isolated Power Plants. K. TOENSFELDT. Combustion, 17: 293–7, 1927. From Chem. Abst., 22: 1500, May 10, 1928. Advantages of water-walled furnaces discussed in detail. Several types illustrated.—*R. E. Thompson.*

Apparatus for Regulating the Admixture of Medicinal Substances or Other Materials with Running Water. I. ROSENBERG. U. S. 1,664,046, March 27. From Chem. Abst., 22: 1502, May 10, 1928.—*R. E. Thompson.*

The Eletrolytic Destruction of Metals in the Soil. O. HAEHNEL. Korrosion Metallschutz, **3**: 145–9, 1927. From Chem. Abst., **22**: 1562, May 10, 1928. Discussion of corrosion of metals in soil with reference to stray currents, in which it is concluded that presence of weak currents is not sufficient evidence for concluding that corrosion is due to stray currents, and that chemical analysis of corrosion products should supplement stray current measurements. Claimed that influence of stray currents is practically negligible if metal is more than 100 meters distant from source of current. In all cases where electric currents are set°up as result of chemical decomposition of lead cables, the oxidized portions are found where current enters metal and the nitrate, chloride and sulfate where current leaves metal.—*R. E. Thompson.*

The Expansion Coefficient of Cast Iron Pipe. T. W. GREENE and EDWARD HERING. Gas Age-Record, **59**: 187–8, 196, 1927. From Chem. Abst., **22**: 1563, May 10, 1928. Linear coefficient of expansion of 8-inch bronze-welded cast iron pipe was determined by measuring increase in length of line 640 feet long when steam was turned into it. Coefficient was 0.0000113 per degree.—*R. E. Thompson.*

Pulverized Coal in a Large Power Station. T. E. PURCELL. Combustion, **18**: 41–5, 1928. From Chem. Abst., **22**: 1666, May 10, 1928. General discussion of results obtained in several large plants using pulverized coal.—*R. E. Thompson.*

Corrosion of Lead by Mineral Springs. P. KAJA. Z. angew. Chem., **40**: 1167–8, 1927. From Chem. Abst., **22**: 1566, May 10, 1928. Investigation of factors influencing corrosion of lead cables. Corrosion products found were chiefly carbonates and oxides of lead. Attack is attributed to presence of carbonates and other salts in ground water and to concentration cells set up as cable runs through soils containing water of different salt concentrations.—*R. E. Thompson.*

Observations Regarding Self-Decomposition and Corrosion of Lead Coatings and Lead Piping. M. v. SCHWARZ. Korrosion Metallschutz, **4**: 1–5, 1928. From Chem. Abst., **22**: 1566, May 10, 1928. Photomicrographic study was made of lead of varying purity exposed to temperatures somewhat above room temperature. In most cases where self-decomposition occurred it was found that lead had recrystallized and grain size was very large. Rate of recrystallization was decreased by decreasing purity of metal. Corrosion usually follows grain boundaries formed by recrystallization.—*R. E. Tjompson.*

The Addition of Three Per Cent Ox Bile to Endo's Medium to Prevent Overgrowth with Bacillus Proteus, and Its Practical Applications. W. KLEINSORGEN and HELMUT JUSATZ. Centr. Bakt. Parasitenk. I Abt., **104**: 439–93, 1927. From Chem. Abst., **22**: 1609, May 10, 1928. Growth of *B. proteus* on Endo's medium is inhibited by 3 per cent bile, while that of colon typhoid group is not. Higher concentrations of bile will interfere with growth of *B. dysenteriae.*—*R. E. Thompson.*

Adjusting the Hardness of Water, for Lining Pipes with Protective Coatings, etc. J. W. M. BOURGOGNION and C. L. PHILIPS. Brit. 271,079, May 11, 1926. From Chem. Abst., **22**: 1643, May 10, 1928. Temporary hardness of water is increased by adding suitable calcium or magnesium compounds and treated water may then be passed through pipes to deposit protective coating on inner surface of pipe. Carbon dioxide may also be added.—*R. E. Thompson.*

Swimming Pool Disinfection by the Use of Monochloramine. W. OLSZEWSKI. Chem.-Ztg., **52**: 141–2, 1928; cf. C.A., **21**: 618, 784. From Chem. Abst., **22**: 1642, May 10, 1928. Data show that mixture of 0.6 to 0.8 p.p.m. chlorine, 0.6 p.p.m. sodium carbonate, and 0.15 p.p.m. ammonia was effective is destroying all *B. coli* present in filtered Elbe River water. Similarly only 0.3 p.p.m. chlorine, 0.27 p.p.m. sodium carbonate, and 0.05 p.p.m. ammonia were required to purify filtered swimming pool water which had been in use three days. Ammonia is introduced with chlorine to avoid irritation to eyes. Use of monochloramine in swimming pool disinfection is recommended.—*R. E. Thompson.*

Sterilizing Water Electrolytically. P. M. R. SALLES. Brit. 271,721, October 25, 1926. From Chem. Abst., **22**: 1642, May 10, 1928. High voltage (suitably 110 or 220) is used for sterilizing water while cold with production of ozone. Anode may be of platinum or lead-coated.—*R. E. Thompson.*

Influence of Brewery Water on the Composition of Wort and Beer. V. KOUDELKA. Arhiv. Hemiju, **1**: 24–8, 1927. From Chem. Abst., **22**: 1649, May 10, 1928. Water rich in carbonates, particularly of magnesium, is unsuitable for breweries. H-ion concentration is important.—*R. E. Thompson.*

Nessler's Reagent. VASTERLING. Pharm. Ztg., **73**: 311–2, 1928. From Chem. Abst., **22**: 1651, May 10, 1928. A plea for more extended use of FRERICHS and MANNHEIM'S procedure for preparation of Nessler reagent, which is as follows: mix 2.5 grams potassium iodide, 3.5 grams mercuric iodide and 3 grams water in 100-cc. flask, and after effecting solution add 100 grams 15 per cent potassium hydroxide solution. Set aside in ammonia-free compartment for few days, then pour off supernatant clear liquid or pass through asbestos or moist sand. Reagent so prepared is absolutely colorless and is best kept in brown glass containers.—*R. E. Thompson.*

Working with Compressed Chlorine Gas in Practice. ROBERT FREUND. Chem.-Ztg., **52**: 33–4, 1928. From Chem. Abst., **22**: 1656, May 10, 1928. Methods of handling chlorine in commercial cylinders, tank cars, etc., outlined. Precautions are given for guarding against accidents, and specific instances of means taken to meet emergencies are cited.—*R. E. Thompson.*

Stability of Cements in Corrosive Waters. HAEGERMANN. Pit & Quarry, **15**: 11, 67–9, 1928. From Chem. Abst., **22**: 1663, May 10, 1928. Density of concrete is important factor as well as nature of aggregates used and after-treatment of concrete.—*R. E. Thompson.*

Disposal of Pulp and Paper Mill Waste in Pennsylvania. W. L. STEVENSON and F. P. KLUND. Paper Trade J., **85**: No. 24, 45–6, 1927. From Chem. Abst., **22**: 1681, May 10, 1928. Report to Sanitary Water Board of Pennsylvania by Pulp and Paper Waste Disposal Committee of Pennsylvania, outlining method of organization adopted by committee for investigation of pulp and paper waste disposal in state.—*R. E. Thompson.*

New Jersey Studies Paper Wastes. H. P. CROFT, I. R. RIKER, C. W. SPARMAKER and F. E. WHITEHEAD. Paper Trade J., **85**: 17, 117–20, 1927. From Chem. Abst., **22**: 1685, May 10, 1928. Report of stock savings and elimination of stream pollution of mill utilizing old papers and regularly operating under closed white-water system.—*R. E. Thompson.*

Waste Liquor Problem in the Paper and Cellulose Industry; the Purification of Waste Liquor and the Recovery of the Material. F. HOYER. Svenk Pappers-Tid., **30**: 476–8, 506–7, 1927. From Chem. Abst., **22**: 1685, May 10, 1928. Descriptive résumé.—*R. E. Thompson.*

Notes on Micro-Volumetric Analysis; Determination of Iron by Method of J. Knop. A. BENEDETTI-PILCHER. Z. anal. Chem., **73**: 200–16, 1928. From Chem. Abst., **22**: 1742, May 20, 1928. Details given for carrying out iron determination with results reproducible to 0.002 mgm. by reducing with stannous chloride and titrating with dichromate, diphenylamine being used as indicator.—*R. E. Thompson.*

The Determination of Traces of Iodine. I. J. F. MCCLENDON. J. Am. Chem. Soc., **50**: 1093–9, 1928. From Chem. Abst., **22**: 1745, May 20, 1928. Detailed directions given for ashing organic material, liberating traces of iodine with nitrous acid and determining iodine in Duboscq colorimeter. With samples containing 1 mgm. iodine, method is accurate within 1 per cent and is applicable down to 0.001 mgm.—*R. E. Thompson.*

A Thermodynamic Study of Fundamental Corrosion Reactions. W. J. SWEENEY. Trans. Am. Electrochem. Soc., **53**: (preprint), 10 pp., 1928. From Chem. Abst., **22**: 1753, May 20, 1928. Fundamental corrosion reactions of iron in absence of oxygen and the equilibrium among iron, ferrous ion, hydrogen ion, and hydrogen discussed from electromotive and free energy standpoint.—*R. E. Thompson.*

Cast Welding (Fluid Welding). W. HOFFMANN. Z. Ver. deut. Ing., **72**: 215–8, 1928. From Chem. Abst., **22**: 1753, May 20, 1928. Electric arc is commonly used in cast welding. Precautions to be observed are: (1) welding material must approach composition of sample to be welded; (2) welding wires of high carbon or manganese content weld satisfactorily only with plus pole of direct current; (3) heating must be carefully controlled; (4) improvement of weld may be effected by subsequent treatment; (5) welding material must be chosen so as to increase wearing qualities of weld.—*R. E. Thompson.*

Iodine in Drinking Waters. J. B. ORR, W. GODDEN and J. M. DUNDAS. J. Hyg., **27**: 197–9, 1928. From Chem. Abst., **22**: 1816, May 20, 1928. Sand filtration does not decrease iodine content, but softening with lime does. In estimation of iodine, it is better to extract residue on evaporation with 10 cc. hot water if there is much calcium carbonate and determine iodine in filtrate and residue separately. Iodine in sample may be lost on standing unless excess of potassium hydroxide is added at time of collection.—*R. E. Thompson.*

The Separating Surface Between Inland Water and Sea Water on a Sandy Coast. T. NOMITSU and PH. FORCHEHEIMER. Gas- u. Wasserfach, **71**: 124–5, 1928. From Chem. Abst., **22**: 1816, May 20, 1928. Equations given for shape of separating surface between inland fresh water and salt water on a sandy coast.—*R. E. Thompson.*

The Organic Content of the Water of Small Lakes. E. A. BIRGE and CHAUNCEY JUDAY. Proc. Am. Phil. Soc., **66**: 357–72, 1927. From Chem. Abst., **22**: 1816, May 20, 1928. Lakes of northeastern Wisconsin show great differences in both organic and inorganic content. Lakes with lowest organic content have also little inorganic matter, but lakes with high inorganic content may or may not be high in organic matter. There is no definite relationship between organic and inorganic content. Each lake at all depths appears to preserve general character of mixture of substances obtaining at surface.—*R. E. Thompson.*

The Rôle of Ammonia in the Purification of Water. C. H. H. HAROLD. J. Roy. Sanit. Inst., **48**: 484, 1928. From Chem. Abst., **22**: 1817, May 20, 1928. Highly polluted waters are more easily sterilized with chloramine than with chlorine. Few complaints due to taste were noted in British Army when chloramine was used. Ammonia is of little value in sterilizing relatively pure waters. Directions given for preparing monochloramine and dichloramine.—*R. E. Thompson.*

Purification of Water for Industrial Purposes. D. N. WEEDON. Proc. Am. Assoc. Textile Chem. Colorists, 1928, 77–84; Am. Dyestuff Rept., **17**: 141–8. From Chem. Abst., **22**: 1817, May 20, 1928. Demonstrations and discussions. —*R. E. Thompson.*

Investigation of the Influence of Automatic Water-Level Regulators on Venturi Meters for Boiler Feed Water. M. SCHAACK and H. LOHMANN. Apparatebau, **40**: 50–5, 1928. From Chem. Abst., **22**: 1817, May 20, 1928. Experiments with E. HANNEMANN's regulators "Direkt" are described in detail.—*R. E. Thompson.*

Closed Apparatus for Removing Iron (from Water). A. BATTIGE. Apparatebau, **40**: 37–9, 55–7, 1928; cf. C.A., **22**: 10000. From Chem. Abst., **22**: 1817, May 20, 1928. Data on filter material, size of grain and how placed, path and rate of flow through filter, aëration, and removal of slime from apparatus handling 20 to 30 cubic meters of water per hour.—*R. E. Thompson.*

The Effect of Various Waters on Copper Containers and Pipes. WALTHER RITTER. Apparatebau, **40**: 57–8, 1928. From Chem. Abst., **22**: 1817, May 20, 1928. Experiments show that action on copper is not sufficient to endanger health.—*R. E. Thompson.*

The Significance of the Corrosion Question in Practical Boiler Operation. A. SPLITTGERBER. Korrosion Metallschutz, **3**: 149–53, 1927. From Chem. Abst., **22**: 1817, May 20, 1928. Discussion of influence of chemical nature of feed water, localized overheating, oxygen content of water, boiler pressure, oils in water, and temperature on corrosion of preheaters, boilers, superheaters, turbines, and condensers.—*R. E. Thompson.*

Bacteria Growing on Leather Packing Cause Errors in Sampling. H. H. GERSTEIN. Eng. News-Rec., **101**: 407, 1928. The quality of the unchlorinated water in the tunnels between the intake cribs and pumping stations in Chicago is determined by bacterial analyses of samples of water collected from hand-operated well pumps. Recent analyses indicated sewage pollution of a degree which could not be accounted for. Check samples taken from the main pumps and with deep water sampling apparatus showed no such pollution. The leather packing on the plunger and suction valves in the pump cylinders were examined and found to be contaminated with organisms which conformed to the A. P. H. A. standard test for *B. coli*. Several of these leathers placed in sterile water in Mason jars about one year ago have maintained a prolific growth of these organisms, the number at times reaching as high as several million per cc. The problem has been solved by installation of specially-designed pump pistons which are metallic throughout, the valves being of the ball type. It is pointed out that samples drawn from fire hydrants may be contaminated in same manner.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Man-Hour Costs of Water-Main Trenching and Pipelaying. A. E. WALDEN and A. F. DIDOMENICO. Eng. News-Rec., **101**: 392–5, September 13, 1928. Details given from records kept by Baltimore County Metropolitan District (Baltimore County Water and Electric Company prior to 1924) since 1921. Data collected on excavation of trenches and laying of approximately 730,000 feet of 6- to 20-inch pipe. Until 1928, sand-cast pipe was used, but since then sand-spun iron pipe has also been employed. Jointing material was entirely lead in 1921 and 1922; leadite, with but few exceptions, in 1924; while from 1925 to date, leadite, with lead for every fifth joint, has been used.—*R. E. Thompson*

Blowing Odor out of Water Supply of St. Paul with Air. ROSS A. THUMA. Eng. News-Rec., **101**: 401–2, 1928. Aëration of the water supply of St. Paul, derived from the Mississippi River via Chain of Lakes, has reduced complaints of odors 95 per cent (estimated). Air, under 5 to 6 pounds pressure, is applied from below to the water entering the mixing chamber, alum being applied at the same point from above. Use of from 6,000 to as low as 3,000 cubic feet of air per million gallons has given satisfactory results. The Cl_2 requirement of the water is slightly reduced by aëration, this probably being partially due to increased coagulation efficiency resulting from the agitation effected by aëra-

tion. The average total cost of aëration during a two-year period, including interest and depreciation, was 24 cents per million gallons.—*R. E. Thompson (Courtesy Chem. Abst.).*

Features of Design, Coolidge Multiple-Dome Dam. C. R. Olberg. Eng. News-Rec., **101**: 396–9, September 13, 1928. Details given of design of Coolidge Dam, first multiple-dome dam ever constructed, now nearing completion on Gila River in Arizona, eight months ahead of contract schedule. Structure, for which appropriation of $5,500,000 was authorized by Act of Congress on June 7, 1924, will be used for storage of irrigation water. Selection of this type of dam was result of search for design which would permit completion of project within limited funds available. Absence of even minute cracks in the 3 concrete domes, 251 feet high and 180 feet wide, in which there are no contraction joints of any kind, is source of satisfaction to all connected with work.—*R. E. Thompson.*

Construction Features of Coolidge Multiple-Dome Dam. Eng. News-Rec., **101**: 438–42, September 20, 1928. Details of construction given.—*R. E. Thompson.*

The Pollution of Tidal and Non-Tidal Waters. J. H. Coste. J. Soc. Chem. Ind., **47**: 133–9T, 1928. From Chem. Abst., **22**: 2802, August 10, 1928. Review of conditions in England.—*R. E. Thompson.*

Some Characteristics of Colliery Surface and Mine Waters. N. Simkin. J. Soc. Chem. Ind., **47**: 114–6T, 1928. From Chem. Abst., **22**: 2652, July 20, 1928. Brief survey of waters available at collierics.—*R. E. Thompson.*

Plan of Water Works Management at Madison, Wis. L. A. Smith. Eng. News-Rec., **101**: 400–1, September 13, 1928. Administration of Madison water works system described. During last ten years, value of water works, exclusive of special assessments, has increased from approximately $1,000,000 to more than $2,000,000. In 1918 the profit, after paying operating expenses, including taxes and depreciation, amounted to less than $25,000; while in 1927, without any change in rates, profit amounted to nearly $100.000. Average annual water bill in Wisconsin cities of more than 10,000 population, based upon annual consumption of 10,000 cubic feet, is $22.20. Annual water bill in Madison on same basis is only $11.50. System is administered by board of 5 water commissioners, including mayor and member of city council, both ex-officio, and 3 others appointed by council (one each year for three-year term) who serve without remuneration.—*R. E. Thompson.*

New Haven's Water Supply to be Increased by 45 M.G.D. Eng. News-Rec., **101**: 391, September 13, 1928. Development by New Haven Water Co. of 53 square miles of watershed in long-inhabited low hills of southern Connecticut will add 45 m.g.d., delivered by gravity, to present supply of 27 m.g.d. Work now under way in North Branford district covers drainage area of 18 square miles and will supply 15 m.g.d. Rights have been acquired for future develop-

ment of 35 square miles of watershed east of North Branford district which will furnish additional 30 m.g.d. Details of new and proposed collecting works given. Present supply is drawn from 98 square miles of watershed with combined storage of 3333 m.g. About half supply is by gravity.—*R. E. Thompson.*

The Merits of Seven Kinds of Pumping Equipment Compared. PAUL HANSEN. Eng. News-Rec., **101**: 386–8, September 13, 1928. Considerable data presented regarding considerations which lead to choice of electrically-driven centrifugal pumping units with gasoline-engine-driven stand-bys for new Highland Park, Mich., pumping station and filter plant. Works serve 3 towns, Highland Park, Highwood, and Deerfield, all suburban in character. On basis that it is permissible for filter plants to be operated 40 per cent over capacity on days of maximum consumption, capacity for immediate installation was estimated to be 7 m.g.d., and additional capacity that might be required in twenty-five years, 3.5 m.g.d. Method of arriving at these values is outlined. Alternative methods of financing proposed improvement were considered: the so-called water certificate plan and revenue bond plan. First is permitted under state legislation of 1899 and latter under new statute passed in 1927. Both laws permit financing of water works improvements by issuing securities which are not included in bonded indebtedness of municipality payable out of general taxation, which, under the Constitution, is limited to 5 per cent of assessed valuation. Both water certificates and water revenue bonds constitute mortgage on works actually constructed from proceeds of their sale. This renders it impossible to incorporate existing structures into the works because they may not be mortgaged. Only way in which existing equipment may be used is to sell it and buy it back again. Water certificate law has further limitations which prevent enlargement or improvement of works until issue has been retired. Under newer law, securities can be refunded at any time and new and larger issue authorized for purpose of financing additions. Latter method was adopted.—*R. E. Thompson.*

Swimming Bath Purification by Chlorine. Cont. Rec. and Eng. Rev., **42**: 615–6, June 6, 1928. Brief description of purification plant at Windsor Central Baths of Bradford, Eng. Pool is 100 by 30 feet, and has capacity of 102,000 gallons. Treatment plant consists of rough strainer, 3 pressure filters, aërator (compressed air), chlorinating apparatus, and clarifiers. Capacity is equal to complete replacement of pool water every three and one-half hours. Coagulant will be employed.—*R. E. Thompson.*

Covered Reservoir Combines Precast and Poured Concrete. GEO. D. REICHERT. Eng. News-Rec., **101**: 380–5, September 13, 1928. Illustrated description of construction of Stacy Park reservoir, St. Louis. This 100 million gallon storage and service basin connecting new Howard Bend plant on Missouri River and present distribution system is 806 feet long and 603 feet wide, having reinforced-concrete floor and roof. Roof is two-way continuous beam and slab structure supported by 1724 precast concrete columns spaced 16½ feet on centers and tied together in groups of four by precast struts at about mid-height. All connections were made by welding together the projecting

reinforcing bars and enclosing in fillet of poured concrete. Entire wall is surrounded by earth backfill 22 feet wide on top and sloping 1 on 2½ to original ground level. Three walls are buttressed every 10½ feet on outside and fourth, designed as division wall between present basin and future extension, every 10 feet both inside and outside. Site is 7 miles west of city limits and 10 miles east of Howard Bend pumping station, and is of sufficient height to give static head of 190 feet at connection with city mains. Contract will aggrega'e $1,220,000.—*R. E. Thompson.*

Placing Gate Valves Under Water in Reservoir. CHAS. B. BURDICK. Eng. News-Rec., **101**: 389–91, September 13, 1928. Crescent Hill station of Louisville, Ky., completed twenty-five years ago, includes 27 m.g. clear water reservoir 363 by 436 feet in plan, carrying about 23 feet of water when full. Reservoir is of plain concrete built on rock bottom. Vertical side walls are approximately 14 feet thick and roof is of groined arch construction. Three cross-walls of plain concrete, 4 feet thick, separate reservoir into 4 divisions, although 2 archways through each wall prevent isolation of the compartments. Installation without putting reservoir out of service, of sluice gates at archways in one division wall and of new external connections described and illustrated.—*R. E. Thompson.*

Universal Water Metering Nears Completion in Jersey City. Eng. News-Rec., **101**: 407–8, September 13, 1928. In November, 1926, program of installing meters on all services was started and on July 1 about 33,000 of the 37,000 service connections, or some 90 per cent, were metered, compared with 38 per cent when work started. Survey was made and notices sent giving owners thirty days in which to install meters. If first notice was not complied with, a second was sent allowing fifteen days' additional time. Upon expiration of this period bureau proceeded with installation and added cost to next regular water bill. This bill becomes lien on property in two years and amount due is collected through tax sales. Plumbers employed by bureau installed average of 1½ meters per day. When owner makes installation, plumber employed by him secures permit and when ready to set meter notifies bureau; meter assigned to that service is promptly furnished and set by bureau. Practice re services and meters is outlined. Charge for meter water is 90 cents per 1000 cubic feet regardless of volume registered.—*R. E. Thompson.*

New Water Works for Town of Blenheim, Ont. L. W. WYNNE-ROBERTS. Contract Rec. and Eng. Rev., **42**: 261, 269, March 7, 1928. Recently completed water works system of Blenheim described briefly. Works consist of two 3-inch wells from which water is pumped by air-lift to small standpipe, thence flowing by gravity to 80,000-gallon concrete reservoir. From latter, water is pumped by electrically-driven centrifugal pump to 50,000-gallon elevated steel tank which maintains pressure of 55 pounds in distribution system. Installation is almost entirely automatic, compressor being started by electric contact from float in reservoir and domestic pumps started and stopped by fluctuations of pressure recorder. Cost, including distribution system, was $83,000. Water was previously supplied by 5 private syndicates, each of which owned a well.—*R. E. Thompson.*

Storage Yards and Buildings of Denver Water Works. Eng. News-Rec., 101: 403–7, September 13, 1928. Detailed, illustrated description of storage of materials for Denver municipal water works. Arrangement is such that inventory of the 2380 items can be made, including nuts and bolts and similar small items, in two to three hours. Owing to distance of works from source of many water works materials, considerable stock must be carried.—*R. E. Thompson.*

The Merits of a Gravity Water Supply. M. E. SMITH. Cont. Rec. and Eng. Rev., 42: 451–7, May 2, 1928. Extensive discussion of advantages of elevated storage, including reduction in size of transmission mains, more economical operation of pumps, dependable supply for fire protection and elimination of extreme variations in pumping pressure. Two examples are given of elevated steel tanks enclosed in masonry and brick to achieve desired architectural effect.—*R. E. Thompson.*

Automatic Pipe-Break Valves on Mokelumne Aqueduct. Eng. News-Rec., 101: 478–9, September 27, 1928. To protect 54- and 65-inch steel pipe aqueduct of East Bay Municipal Utility District, extending from Pardee supply reservoir on Mokelumne River to Oakland, Cal., 4 automatic shutoff valves and blowoffs have been installed in pipe line. In case of break downstream of one of these valves, increased rate of flow through valve will automatically operate motor-driven closing mechanism, shutting butterfly valve in pipe. At same time, to avoid rise of pressure on supply side of shutoff and thus make it unnecessary to provide extra strength in pipe to withstand this greater pressure, wasteway or blowoff is opened in such way as to maintain substantially normal rate of flow through upper portion of aqueduct. These valves have been installed at Bear Creek, 8 miles from reservoir; San Joaquin River, 35 miles; Indian Slough, 48 miles; and Clyde Wasteway, 74 miles. General arrangement was suggested by F. W. HANNA.—*R. E. Thompson.*

Concrete Spur Dikes Maintain Deep River Channel. LLOYD B. SMITH. Eng. News-Rec., 101: 434–5, September 20, 1928. Illustrated description of methods employed to prevent shifting of river bed from intake of Topeka, Kansas, water works, which was 100 feet from shore when built in 1921. Retards were placed at time intake was constructed, some of which had to be replaced following heavy flood shortly after. Additional retards were placed in 1927 consisting of 4 reinforced-concrete arms 5-inches in diameter cast individually and held in place by reinforced-concrete center block. As result, minimum depth of 7 feet has been maintained at intake.—*R. E. Thompson.*

Should Engineers on Appraisal Work Tell the Truth? GREGORY M. DEXTER. Eng. News-Rec., 101: 436–7, September 20, 1928. General discussion of appraising.—*R. E. Thompson.*

Graphical Cross-Sections Recorded by Tunnel Pantograph. Eng. News-Rec. 101, 481, September 27, 1928. Brief illustrated description of tunnel pantograph by means of which graphical representation of tunnel-cross sections can

rapidly and easily be obtained without measuring and plotting. Ratio of diagrams to actual size is 30 to 1. Instrument was employed in 12½-foot diameter horseshoe section of Cobble Mountain diversion tunnel, Springfield, Mass., water supply system.—*R. E. Thompson.*

New Cooling Apparatus Cracks Off Scale. Oil and Gas J., **26**: 51, 76, 1928. From Chem. Abst., **22**: 2802, August 10, 1928. Cooler or condenser developed by Griscom-Russel Co., consists of series of Admiralty metal tubes set with an initial curvature into cast iron headers. Scale formed on tubes by evaporation of cooling water is automatically cracked off if flow of hot liquid through tubes is interrupted, causing them to return to initial curvature. Same principle is applied to evaporators for distilling pure boiler feed water from hard, dirty or salt water.—*R. E. Thompson.*

Algae Control by Creating Turbidity at Louisville, Ky. W. H. Lovejoy. Eng. News-Rec., **101**: 505–7 (1928). Filter runs are seriously reduced by algae during certain periods at the Louisville plant; they have been as short as thirty to sixty minutes and wash water as high as 12 per cent of the water filtered. It was observed that this condition obtained when the turbidity of the raw water was low, an increase of as little as 50 to 75 p.p.m. of turbidity causing disappearance of the algae and lengthening of the filter runs. During two periods in 1927 low runs were successfully combated by artificially increasing the turbidity by pumping sludge from the bottom of the preliminary settling basins to the raw water inlet of the basins by means of a dredge boat carrying an 8-inches electrically-operated dredge pump. Five hours operation of the dredge causes sufficient stirring up to give a turbidity of 500 at the inlet of the basins for 24 hours. About 80 per cent of this turbidity settles in the 2 preliminary basins removing a large number of organisms, and the remaining 100 p.p.m. of turbidity provides a nucleus for an excellent floc in the coagulation basin which carries down an additional number of organisms. During the treatment the bacterial count and *B. coli* content of the water leaving the basins were lower than in the incoming raw water. Observations have indicated that shortening of the filter runs results from gradual accumulation on the filter sand of algae which are not removed to any great extent by washing. In future it is intended to create artificial turbidity whenever the river water tubidity drops below 50 p.p.m. and runs show any appreciable decrease. It has been found that a filter with sand of 0.48 to 0.50 mm. effective size will run on an average 50 to 100 per cent longer, during short run periods due to algae, than one having sand of 0.40 mm. effective size; and that the unit with the finer sand will drop off in length of runs more rapidly and regain more slowly than the one with coarser sand. The following treatments were experimented with previously: $CuSO_4$; line; overdosing with alum; coagulation with Na aluminate and alum; and prechlorination. In addition. the filter sand has been treated with $CuSO_4$, NaOH and hypochlorite. Alone of these, $CuSO_4$ treatment gave even temporary relief, and then only when subsidence period was four days or more. The dredge is also used for cleaning the basins without draining, the cost being about 3 cents per cubic yard.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Performance and Cost Records in Guniting a Tank. F. W. MacLennan. Eng. News-Rec., 101: 708–9, November 8, 1928. Description of guniting of bottom of dewatering tank of Miami Copper Company, Miami, Ariz. Tank is 6 feet deep at edges, 29 feet deep at center and 325 feet in diameter. Tightness was particularly essential. Bottom was made 2½ inches thick, with reinforcement of 4 by 4-inch mesh welded fabric of No. 7 wire. A 1:3½ gunite was employed. Area covered was 86,854 square feet, and cost was 14.942 cents per square foot or $22.65 per cubic yard, exclusive of power, plant charges, overhead, and profit.—*R. E. Thompson.*

Subaqueous Conduit Built Without Unwatering Site. Eng. News-Rec., 101: 734–5, November 15, 1928. Illustrated description of construction of new cooling-water intake for standby steam-electric station of Pacific Gas and Electric Company, situated on shore of San Francisco Bay. Total length is 438 feet, almost half of which is in firm ground, where it was feasible to unwater trench and pour concrete in open cut. About 210 feet on outer end had to be classed as subaqueous work because of depth and soft quality of surrounding mud. Latter section was constructed by employing concrete sheet piling for sides and a layer of tremie concrete for bottom or floor. Top was constructed of reinforced concrete in the dry.—*R. E. Thompson.*

Flood Control Through Slope Correction. Eng. News-Rec., 101: 631–3, October 25, 1928. Discussion of article of W. E. Elam, by J. R. Slattery, C. McD. Townsend, Roy N. Towl, and John F. Coleman, and reply by W. E. Elam.—*R. E. Thompson.*

Roller Gates on Dams Not Confined to Scandinavia and Germany. John V. Zahlen. Eng. News-Rec., 101: 816, November 29, 1928. Applications of roller gates discussed and data given on existing gates.—*R. E. Thompson.*

Specifications for Steel Pipe for Wanaque Aqueduct. Eng. News-Rec., 101: 889–91, December 13, 1929. Details given of specifications on which bids were asked on construction of aqueduct to be built by North Jersey District Water Supply Commission. Aqueduct will be over 6 feet in diameter and about 20 miles in length, not including tunnels already constructed. As its upper end will consist of twin pipes, the total length will be 164,100 feet. Specifications require that hydrostatic tests of finished pipe in shop shall be made under pressure of 175 pounds per square inch and field tests under 125 pounds pressure, latter to show not more than 8500 gallons leakage per mile of pipe per twenty-four hours in any section. After each section is finished and tested it must be sterilized with chlorinated lime (at least 2½ pounds per 100 linear feet) dissolved in water. Details included regarding the engineering controversy which has been going on for some years in connection with this aqueduct.—*R. E. Thompson.*

Metcalf and Eddy Report on Wanaque Aqueduct. Eng. News-Rec., 101: 961, December 27, 1928. Conclusions are as follows: Twin steel lines of present plan have not sufficient capacity unless supplemented by pumping at

dam. Installation of pumping station at Wanaque dam is undesirable. Twin steel lines are unnecessary and expensive as compared with single line of equal capacity. More permanent and economical aqueduct can be obtained through use of single steel pipe, with cement mortar lining and outside concrete protection, of sufficient size to provide for maximum flow without pumping. Brief additional data from report also included.—*R. E. Thompson.*

Mississippi River Flood Control. C. S. HILL. **I. Volume of Work and Construction Conditions.** Eng. News-Rec., **102**: 90–3, January 17, 1929. **II. Levee Construction Methods and Plants.** Ibid., 142–5, January 24, 1929. **III. Revetment Construction Plant and Methods.** Ibid., 182–5, January 31. Review of construction conditions of ten-year flood control project on Mississippi which will cost $325,000,000.—*R. E. Thompson.*

Sedimentation Study in the Mississippi River. ALVIN L. LUGN. Augustana College, Rock Island, Ill., Monograph, 104 pp. Eng. News-Rec., **101**: 691, November 8, 1928. This monograph consists of a report on one unit (Davenport to Cairo) of comprehensive study of sediments in Mississippi River and the phenomena surrounding their carriage and deposition being conducted by A. C. TROWBRIDGE, State University of Iowa. Mechanical analyses of 235 samples of sediment and suspended matter collected in 1925 and 1926 over distance of 500 miles were made. Most important factor which maintains sediment suspended and in motion downstream is the turbulence of the water, i.e., the number and strength of eddy currents, whirls, boils, etc. It is believed that effectiveness of this turbulence in maintaining sediment in suspension varies in same ratio as competency is supposed to vary with average forward velocity of the current. Thus, if competency varies as fifth or sixth power of forward velocity, it does so because the effectiveness of turbulence, as above understood, varies in same ratio. A river's maximum capacity and greatest competency are attained only during times of high water and then only for periods of short duration, since volume of water is most important factor affecting competency, gradient being minor factor. Width and depth of channel affect velocity in few places. Under some conditions, not as yet fully analyzed, quantities of sediment are maintained in state of semi-suspension on bottom of river. This phenomenon was observed in shallow water near banks at many places in Mississippi above mouth of Missouri River, being never more than few inches thick. All such mud contains considerable amount of fine sand and coarse silt grades in addition to much clay. Six general types of Mississippi sediment are distinguishable by mechanical analysis.—*R. E. Thompson.*

Need of a National Hydraulic Research Laboratory. BLAKE R. VAN LEER. Eng. News-Rec., **102**: 68–71, January 10, 1929. Discussion of value of hydraulic research laboratories in solving such problems as Mississippi flood control, with data on European laboratories. There is ample work for at least two such laboratories in United States.—*R. E. Thompson.*

Our Future in Hydraulic Research. Eng. News-Rec., 102: 71, January 10, 1929. Further discussion (cf. previous abstract), signed C. H.—*R. E. Thompson.*

"Reasonable Use" of Water Awaits Adjudication in California. Eng. News-Rec., 102: 102, January 17, 1929. On November 6 the people of California by popular vote ratified a constitutional amendment that had been passed by last legislature revising water law of state, particularly in matter of riparian rights. Portion of new law requires that waste or unreasonable use or unreasonable method of use of water be prevented, and that conservation of such waters be exercised with view to reasonable and beneficial use thereof in interests of people and for public welfare. Right to water or to use or flow of water in or from any natural stream or watercourse is limited to such water as shall reasonably be required for beneficial use to be served, and such right does not extend to waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water. Question of constitutionality of law has been raised and one court decision has implied that amendment is invalid i.e., that state could not authorize the riparian right of any individual to be taken from him without compensating that individual for his loss. It is believed that effect of new amendment will depend to large extent upon the construction which court gives to the word "reasonable." There is doubt, also, as to whether, in case where unreasonable methods of use now existent, such as natural overflow, have some monetary value to riparian owner, the constitutionality of the act can be sustained.—*R. E. Thompson.*

The Question of Veneered Concrete. FRANZ KREUTER. Eng. News-Rec., 101: 710, November 8, 1928. Value of veneering concrete, as in dams, with ashlar or brick is questioned, as is also the value of expansion joints in concrete dams.—*R. E. Thompson.*

Iron Pipe Fifty-eight Years Old is Reinstalled as Penstock. GEO. A. HUNT. Eng. News-Rec., 101: 740, November 15, 1928. Wrought iron pipe installed for hydraulic mining service in California fifity-eight years ago was recently removed from the ground and, after being tested and reconditioned, relaid as penstock supplying Centerville hydro-electric plant of Pacific Gas and Electric Company. Penstock will operate under maximum head of less than 570 feet. Pipe had been thoroughly painted inside and out with a black protective coating material and line had been in continuous operation only during first fifteen to twenty years of its existence. Before relaying, pipe was thoroughly cleaned and immersed in a hot petroleum compound until pipe and coating material had uniform temperature of 250°. About $\frac{1}{16}$ inch of compound adhered to pipe after draining, and outer surface of this was protected by applying sand while coating was hot.—*R. E. Thompson.*

Truss-Braced Circular Cofferdam Used in Constructing Intake. L. J. JORDAN. Eng. News-Rec., 101: 770–1, November 22, 1928. Illustrated description of construction of raw water intake to pumping plant of Lancaster Cotton Mills, Lancaster, S. C. Intake, 12 by 14 feet inside dimensions with

21-inch walls, is located in Catawba River. As it was important that no cofferdam bracing pass through concrete walls of intake structure, steel sheet pile circular cofferdam was designed with trussed-timber ring bracing to clear exterior walls.—*R. E. Thompson.*

Roof Protection for Muckers in Tunnel Headings. Eng. News-Rec., **101**: 707–8, November 8, 1928. Method of protecting muckers in mine drifts is described by G. TOWNSEND HARLEY in Explosives Engineer, which may be applicable also in tunnel headings.—*R. E. Thompson.*

Wet Tunnel Strengthened and Made Tight by False Roof. S. E. BERKENBLIT. Eng. News-Rec., **101**: 655–6, November 1, 1928. Description of waterproofing and reinforcing of old tunnel for Kansas City Public Service Company, by construction of false roof and use of waterproofing plaster.—*R. E. Thompson.*

Meter Placing and Maintenance in New York Water Department. Eng. News-Rec., **101**: 579, October 18, 1928. Meter practice in New York City outlined. Metering is optional except where water is furnished for commercial use, in which case installation of meter may be demanded. Unmetered water is sold at flat rate, varying with frontage, height, and fixtures of building and number of families residing therein. Number of services is 570,000, of which 138,000 (24 per cent) are metered. Property owner is required to pay all expenses of meter, its connection, setting, and repair. He has choice of number of approved makes of meters. Placing and repairing is performed only by licensed plumbers after obtaining permit from department. Stock of meters which have been tested and approved is kept on hand at meter shop, no charge being made for testing. These meters are the property of the various meter companies and are kept on hand merely to facilitate distribution. Metered water is paid for at rate of 10 cents per 100 cubic feet, with no minimum charge.—*R. E. Thompson.*

Quick-Hardening Cement Used in Winter Repairs to Reservoir. CLARENCE E. CARTER. Eng. News-Rec., **101**: 557, October 11, 1928. Description of repair of Folly Hill reservoir at Salem, Mass., which is 26 feet deep and has groined arch roof, walls depending upon aid of passive pressure of surrounding earth embankment to resist water pressure. Crack appeared at one corner, 1½ inches wide at top with others radiating from it, apparently due to settlement of embankment. Repairs consisted of tying of top corner of walls together with reinforced concrete strip; bracing each wall near corner with reinforcing concrete butresses extending about 2 feet beneath floor of reservoir into hard natural material; and filling all cracks with gunite. "Ferrocrete" was employed, this cement reaching full strength in four days.—*R. E. Thompson.*

Operation of New York City High-Pressure Fire System. Eng. News-Rec., **101**: 704, November 8, 1928. Description of high-pressure system used for fire protection in lower portion of Borough of Manhattan, New York City, which was first placed in operation in 1908. System consists of 128 miles of 12- to 24-inch cast iron pipe and 2746 fire hydrants. There are 2 electrically-

operated pumping stations in easterly and westerly portions of district respectively, each containing 6 centrifugal units of 3000 to 5000 gallons per minute capacity. Water is available from Catskill and Croton supplies, and also from salt water intakes. Latter has never been used. When alarm is sounded, pressure in system is built up to 125 pounds per square inch. Electric current supply is obtained through 4 direct feeder lines, any one being capable of operating all of the pumps. Current is supplied over feeders at 11,000 volts and is stepped down to 6600 volts at stations, all motors operating at latter voltage with exception of small direct-current motors used for operating control mechanisms. Area on East Side is covered by a duplex system. Mains on alternate streets are connected in one system, while those in remaining streets are connected to another system. Should break occur, one system can be shut down without interfering with the other. System is controlled by telephone, fire department having complete control over pressure maintained during fires. Records show that water is used from system on only about 10 per cent of occasions that pumps are placed in commission. Water pumped into system is recorded by Venturi meters.—*R. E. Thompson.*

Largest Steam Turbine Under Construction. Eng. News-Rec., 101: 627, October 25, 1928. Turbo-generator now under construction for New York Edison Co., is believed to be largest single-shaft, single-unit generator in world. It will be located in new East River generating station, and will develop 160,000 kw., or 215,000 h.p. Steam-generating units will also be of unprecedented size. Four units will be installed, having aggregate heating surface of 45,120 square feet each, and producing 550,000 pounds of steam per hour each. Station will contain largest pumping plant in world, total capacity of circulating pumps of condensers being 1,400,000 gallons of water per minute. —*R. E. Thompson.*

Weld Efficiency in Penstock Pipe Using Overlap Welds. OREN REED. Eng. News-Rec., 101: 550–2, 1928. Curves are given, based on data obtained in tests of 522 welded pipe sections, showing weld efficiency and ultimate weld strength. The variation in weld strength with plate thickness is shown graphically. A plate of $\frac{5}{8}$ to $1\frac{1}{8}$ inch in thickness will give the most consistently good welds. In general, the weld efficiency of 90 per cent often assumed in designing penstocks is conservative, but for thin plates (less than $\frac{7}{16}$ or $\frac{1}{2}$ inch) a lower efficiency should be assumed. The data given indicate that a maximum thickness of $1\frac{1}{4}$ inch or slightly greater can be used conservatively. The minimum weld strength obtained was 41,200 pounds per square inch, representing a weld efficiency of approximately 80 per cent with plate strength of 52,000 pounds per square inch.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Aged Pump Driven By Waterwheel at Alexandria, Va. JAMES H. LE VAN. Eng. News-Rec., 101: 925, December 20, 1928. Brief illustrated description of pump which has continuously supplied Alexandria, Va., 0.8 million gallon of water per day for past seventy-seven years and is still part of regular pumping equipment. This is believed to be record for long service by piece of moving machinery. Pump was originally driven by wooden overshot wheel, replaced

some twenty-five years ago by steel overshot wheel. This wheel is on same shaft as cast iron flywheel, connected with pump by an iron-bound beam 39 feet long. Pump cylinder has 10-inch bore and is 10 feet long. Piston has 9-foot stroke. Pump and flywheel work at 9 revolutions per minute. Pump delivers water to filter plant against head of 110 feet, pulsations being smoothed out by enormous air receiver on discharge pipe. With exception of bronze bearings for connecting rod, pump is made entirely of cast iron. Compared with water-turbine-driven centrifugal pump recently installed in same station, old pump occupies about 8 times the floor space, runs at about $\frac{1}{20}$ the speed and has apparently the same over-all efficiency. Only serious trouble experienced was a large crack which developed in connecting rod and was repaired by bolting flat iron plate on each side of rod.—*R. E. Thompson.*

Filter and Pump Layout for Jackson Water Works. J. H. FERRELL. Eng. News-Rec., 101: 552, 1928. A brief illustrated description of the new plant at Jackson, Miss., treating Pearl River water, which consists of a 7-million gallon raw water reservoir, mixing flumes, coagulation basins, ten 1-million gallon per day rapid sand filters, and a 1-million gallon clear water reservoir. The chemical machines are of the dry-feed type. The pumping plant consists of electrically-driven centrifugal pumps, with steam-driven units for stand-by purposes.—*R. E. Thompson (Courtesy Chem. Abst.).*

Duplex Leaf Valve Designed to Operate Under Pressure. Eng. News-Rec., 101: 913, December 20, 1928. Illustrated description of motor-operated gate valve of novel design recently installed in 10-foot steel pipe line built by Southern California Edison Company as outlet from Huntington Lake to supply the Huntington-Shaver conduit. Valve has capacity of 1400 second-feet and is designed to operate under head of 60 feet. Distinguishing feature is use of 2 rectangular gate leaves in same plane, operated by horizontal stems. This design gives smooth flow in practically all positions and permits ready regulation of discharge. Arrangement also materially reduces size and weight of mechanism and distributes stress among 4 valve stems. Valve has throat diameter of 8 feet, and cast-iron leaves weigh 8000 pounds each. Vertical meeting edges are fitted with bronze seat strips. Opening, by motor, requires nine minutes.—*R. E. Thompson.*

San Gabriel Flood-Control Dam in Immediate Prospect. Eng. News-Rec., 101: 733–4, November 15, 1928. Construction will be commenced on San Gabriel dam of Los Angeles County Flood Control District in immediate future. Estimated time required to complete project is six years. Structure will be of arched gravity type, 425 feet above stream-bed and about 500 feet above deepest rock excavations, and will develop storage capacity of 240,000 acre-feet. Concrete will total about 3,800,000 cubic yards. While primarily for flood control, structure will also be used for conservation of irrigation water.—*R. E. Thompson.*

Water Purification Progress during the Year 1928. NORMAN J. HOWARD. Cont. Rec. and Eng. Rev., 42: 1355–61, 1928. An extensive review and discus-

sion of progress in water purification during the past year. A brief description is included of coagulation studies being conducted in connection with the design of the 200-million gallon per day filter plant extension at Toronto. Mechanical and static agitation are being compared. The latter consists of passing the water through a basin divided into a number of compartments by perforated partitions, the number of perforations increasing in each successive partition. The velocity of the water entering the basin is thus employed to provide the necessary agitation, and the velocity is so reduced before leaving the basin as to largely eliminate short-circuiting in the coagulation basin. Super- and de-chlorination has been successfully employed at Toronto to eliminate chlorophenol tastes since June, 1927. Not a single complaint of taste was received during 1928. The average amount of water treated during a twelve-month period was 74.76 million Imperial gallons per day, the maximum dosage of Cl_2 being 2.5 p.p.m., and of SO_2, 2.0 p.p.m. The cost of the treatment was $0.78 per million Imperial gallons or 3.5 cents per capita per annum. A fire pump water chlorinator, which operates automatically when the pump is put into commission, is described which has recently been developed for use on cross-connections between public and private water supplies.—*R. E. Thompson* (*Courtesy Chem. Abst.*)

Earth Dam Temporarily Repaired After Partial Washout. Eng. News-Rec., 101: 915, December 20, 1928. Brief description of repair of 63-foot Pleasant Valley earth- and rock-fill dam of Price River Conservation District, Utah, which was partially washed out on May 21, 1928. Board of engineers appointed to review the situation reported that accident was due to shrinkage cracks caused by drying out of material of dam, washing out of fine material of earth-fill or upstream part through the rock-fill portion and subsequent caving in of earth above.—*R. E. Thompson.*

An Unpurified Pure Water. F. T. UNDERHILL. Pub. Health J. (Canadian), 19: 463–5, 1928. Brief details are given of the water supply of the Greater Vancouver Water District, which is derived from two mountain streams, Capilano River and Seymour Creek, and distributed by gravity without any form of treatment. Logging operations in that portion of the watershed which is not owned by the District or situated in the forest reserve, are strictly supervised. Every individual must show a negative Widal test before being admitted to the watershed, and fishing and hunting are prohibited. The average composition of the Capilano and Seymour waters, respectively, during 1927 was as follows, in parts per million: total solids, 37.20 and 45.35; chlorides, 2.69 and 2.73; free NH_3, 0.017 and 0.025; albuminoid NH_3, 0.027 and 0.032; N as N_2O_5, 0.58 and 0.62; N as N_2O_3, nil; reaction neutral. The average bacterial counts were 21 and 40 per cc., respectively.—*R. E. Thompson* (*Courtesy Chem. Abst.*)

Water Main Reinforcement Need Shown by Surveys. Eng. News-Rec., 101: 739, November 15, 1928. Determining hydraulic gradient of distribution system has been practised for number of years by Department of Water Supply, New York City, as means of locating low-pressure or relatively high-

consumption areas. Pressures at several hundred points scattered over entire system are determined by means of gages attached to fire hydrants of known elevation and converted into heads in feet above mean sea level datum. Brief details given.—*R. E. Thompson.*

Engineering Problems of the Chicago Region and Their Solution. W. W. De Berard. Eng. News-Rec., 101: 758–64, November 22, 1929. Discussion of regional problems of Chicago and vicinity. Ground water supply used by many cities is being depleted at rapid rate, falling in some cases as much as 12 feet per year. Metropolitan system for region is inevitable.—*R. E. Thompson.*

Further Instances of Use of Artificial Turbidity for Algae Control. Lewis V. Carpenter. Eng. News-Rec., 101: 852, 1928. Cf. C.A., 22: 4682. Two instances are cited of the use of added turbidity for algae removal. During the summer of 1924 trouble was experienced at Huntington, W. Va., with the filters becoming clogged by *Synedra*. Copper sulfate and prechlorination killed the organisms, but they remained in suspension. Addition of sufficient clay to increase the turbidity from 8 to 10 to 50 to 75 p.p.m., aided settling out of the dead organisms and materially increased the length of the filter runs. During the summer of 1925, dry clay was added to the raw water at Evanston, Ill., through a dry feed machine as an aid to algae removal.—*R. E. Thompson* (*Courtesy Chem. Abst.*)

No Extras for Mains in Paved Streets. Eng. News-Rec., 101: 552, October 11, 1928. Arbitration proceedings fixed value of Tillsonburg, Ont., water works at $100,000, no extra allowance being made for paving placed after mains had been laid: purchase at this price being ratified by electorate on September 10.—*R. E. Thompson.*

Progress on the Cascade Tunnel, Great Northern Railway. Eng. News-Rec., 101: 555, October 11, 1928. Up to August 31, 1928, main tunnel had been completed to full section for aggregate length of 7 miles and concrete lining had been placed for 6 miles. Total length is 7¾ miles. Data on construction included.—*R. E. Thompson.*

Study of Record Rainstorm at Louisville, Ky. Woolsey M. Caye. Eng. News-Rec., 101: 587–9, October 18, 1928. Data given on most intense rainfall experienced at Louisville during thirty-one years for which records are available, which occurred on June 29, 1928, rate being 4.68 inches per hour at thirty-minute duration period compared with previously recorded maximum of 3.44 inches.—*R. E. Thompson.*

Another Instance of Heavy Rainfall. Arthur M. Shaw. Eng. News-Rec., 101: 668, November 1, 1928. Cumulative rainfall graph given for fall of rain in New Orleans on April 15–16, 1927. Data shown are as follow: twenty-four-hour total, 14.01 inch; one-hour maximum 2.34; twelve-hour maximum 12.7; hourly rate for twelve hours 1.06.—*R. E. Thompson.*

Record Precipitation and Wind Reported from Porto Rico. Eng. News-Rec., 101: 798, November 29, 1928. Rainfall on September 13 and 14, 1928, reported to be in excess of 25 inches, one town reporting fall of 29.60 inches.—*R. E. Thompson.*

Arizona Views on Compromise on the Colorado River. THOMAS MADDOCK. Eng. News-Rec., 101: 782, November 22, 1928. Discussion of Arizona-California Colorado River controversy from viewpoint of former state.—*R. E. Thompson.*

Baffle Boxes Absorb Energy from High-Head Blowoff Valves. F. W. HANNA. Eng. News-Rec., 101: 778, November 22, 1928. In designing aqueduct which is to convey water from Mokelumne River project being developed by East Bay Municipal Utility District, it was necessary to provide for occasional discharge of water from main aqueduct into waste channels under comparatively high heads. Concrete baffle box developed to absorb energy of the discharging water to prevent destructive erosion described.—*R. E. Thompson.*

Application Form for Cross-Connections in New Jersey. Eng. News-Rec., 101: 776, November 22, 1928. Description of form adopted by New Jersey State Department of Health for applications for cross-connections between public potable water supply and unapproved supply.—*R. E. Thompson.*

Condition of the Boyds Corners Dam. E. C. LA RUE. Eng. News-Rec., 101: 561, October 11, 1928. Brief discussion of condition of dam as reported by W. W. BRUSH.—*R. E. Thompson.*

Significant Tests of Frost Action on Concrete. WILLIAM H. BATCHELDER. Eng. News-Rec., 101: 882, 1928. Tests were made by Minnesota Highway Dept. of frost action on concrete mixed and cured under wet burlap at 70°F. (A) and at 40°F. (B). Freezing immediately after casting resulted in 31 per cent loss of strength in A and 69 per cent in B. If concrete was protected for seven days before freezing, these percentages were reduced to 0 and 3.5 respectively. Concrete is not greatly harmed by frost after twenty-four to seventy-two hours curing if subsequently given good curing. Two weeks freezing has little more effect than sixteen hours, except, of course, that the strength does not increase while concrete is frozen. Effect of alternate freezing and thawing is marked, if freezing commences immediately after casting, but decreases with additional initial curing.—*R. E. Thompson* (*Courtesy Chem Abst.*).

Hydraulic Chart for Determining Flow in Conduits and Channels. CHAS. E. SHARP, Jr. Eng. News-Rec., 101: 706–7, November 8, 1928. Chart given by means of which complex problems involving flow of water through open and closed conductors can be solved without usual cut-and-try balancing of sets of independent calculations. Superimposed upon main chart are 2 auxiliary diagrams for determining, for any section, the "equivalent rectangle" which has same hydranlic characteristics. It has been found that water conduits of

commonly used shapes may be quite accurately resolved into an equivalent rectangle by considering invert and sidewall heights and arch rise.—*R. E. Thompson.*

Man-Hour Costs of Water Main Trenching and Pipe Laying. T. F. YOUNG. Eng. News-Rec., 101: 816–7, November 29, 1928. Methods employed and cost data given for 14-mile, 48-inch cast iron pipe line with lead joints constructed for London, England, in 1924–5. Specifications required test-pressure of 260 pounds per square inch.—*R. E. Thompson.*

New and Simple Method for Determining Moisture Content in Aggregates. WALTER M. DUNAGAN. Eng. News-Rec., 101: 738–9, 1928. A direct weight displacement method for determining the moisture content of aggregates is described which is believed to be more rapid and less subject to error than other current methods. The time required to carry out a test need not exceed five minutes. (See following abstract.)—*R. E. Thompson (Courtesy Chem. Abst.).*

Determining Moisture Content in Aggregates. H. C. MCCALL. Eng. News-Rec., 101: 966, 1928. Discussion of paper by W. M. DUNAGAN (cf. previous abstract) in which attention is drawn to errors to which method suggested by W. M. DUNAGAN is subject. Method is considered much the simplest and fastest for determining added absorption of porous aggregates which are dry or contain less moisture than the total absorption. Most dependable method for sand is to determine absorption and then obtain total moisture by drying to constant weight.—*R. E. Thompson (Courtesy Chem. Abst.).*

Erecting Water Tank of 1-M.G. Capacity. Eng. News-Rec., 101: 556, October 11, 1928. Brief illustrated description of 1-m.g. tank erected for City of Springfield, Ill. Tank is 72 feet in diameter with cylindrical shell 17 feet deep and elliptical bottom 23 feet deep, top of shell being 100 feet above footings. Work was completed in 3 months by erecting gang of 10 men. No leaks occurred when tank was first filled.—*R. E. Thompson.*

Micrometer Target for Lining Up Machinery With Instrument. Eng. News-Rec., 101: 705, November 8, 1928. Brief description of micrometer target rod for use with engineer's level instrument in setting heavy machinery, designed to give degree of accuracy comparable to that made possible by instrument. Target was used in lining up hydraulic turbine shafts in Buck's Creek hydroelectric plant in California.—*R. E. Thompson.*

Large Tank Equalizes Water Pressure at Springfield, Ill. Eng. News-Rec., 101: 625, October 25, 1928. Brief description of elevated steel tank recently constructed at Springfield, Ill., to equalize pressure in outlying districts and to overcome drops in pressure which occur during maximum demand. Capacity is 1 million gallons, this volume of water floating directly on the distribution system, which is supplied by direct pumping. Tank was put in commission on May 8, and was immediately effective. A 10-foot riser extends 60 feet to

elliptical bottom of tank. Estimates showed that enlarging of facilities and increasing capacity of distribution system to give adequate pressure during peak demands, without elevated storage, would cost about $763,340, while with elevated tank cost would be only $317,975. Of latter amount, tank represented about 20 per cent, remainder being for additional trunk mains to and from tank.—*R. E. Thompson.*

Improving the Water Works System of Evansville, Ind. F. M. VEATCH and H. F. LUTZ. Eng. News-Rec., 101: 880–2, December 13, 1928. Improvements described which are being made to water works system of Evansville to reduce operating costs and anticipate increasing demands for water. Work includes: (1) construction of 20-million gallon covered concrete storage reservoir with 2 supply lines to distribution system; (2) rehabilitation of pumping station; and (3) improvements to filter washing equipment. Supply is derived from Ohio River and is treated in plant consisting of mixing basins, coagulation basins, and rapid sand filters. Population served is 100,000. Consumption rates are approximately 9, 12, and 20 million gallons for average day, maximum day, and maximum hour, respectively. Diagrams are given showing annual installations of pumps of the 4 main types during years 1883–1926 and the storage provided, expressed as percentage of average daily pumpage, in 29 American cities. Former indicates plainly that recent trend in pump installations has been toward steam turbine-driven centrifugal pumps, with motor-driven centrifugal pumps second.—*R. E. Thompson.*

Mount Airy Waterworks. PRESON P. PHILLIPS. Public Works, 59: 347–350, 1929. The new rapid sand filtration plant with a rated capacity of 1.5 m.g.d. is described. The plant includes a rectangular mixing chamber with over and under baffles designed to give a retention period of fifteen minutes, three coagulation basins (one 12 by 72 feet and two 16 by 72 feet) with a retention period of five hours, and three filters.—*C. C. Ruchhoft.*

Water Supply, Sewage Treatment and Refuse Disposal in 1928. H. BURDETT CLEVELAND. Public Works, 60: 34–36, 1929. A brief review of progress and of completed and projected improvements.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Upper San Leandro Water Project. CHARLES W. GEIGER. Public Works, 59: 473–4, 1928. This project consists of a dam creating a reservoir 6 miles long, a supply tunnel, a filtration plant, and the connecting pipe lines. The reservoir impounds water from a watershed of more than 30 square miles and has a capacity of 16,000 million gallons. The dam is an earthen structure with a maximum height of 185 feet and a length of 656 feet at the crest; it is provided with two spillways. The supply tunnel is 7155 feet long and has a cross sectional area of 30 square feet.—*C. C. Ruchhoft.*

Water Purification at Greenwich. Anon. Public Works, 59: 415–19, 1928. The new plant includes a low-lift pumping station, aërators, chemical mixing tanks, coagulation basins, rapid sand filters, a one million gallon clear water basin, and chlorination equipment. Aëration is provided by 48 Sacramento

type nozzles located on the roof of the coagulation tank. There are two chemical mixing tanks equipped with mechanical stirrers. The coagulation basins have a capacity of 6 m.g.d. and the filters, 4 m.g.d. The excess capacity of the coagulation basins is to permit the use of the existing pressure filters. There are 8 new filter units each with a 0.5 m.g.d. capacity at a rate of 125 m.g.d. per acre.—*C. C. Ruchhoft.*

Springfield's New Water Supply Developments. Anon. Public Works, **59**: 333–339, 1928. The construction of a new welded steel pipe line from the Provin Mountain resevoir to and across the Connecticut River to the city is described. The line is 32,740 feet long and includes 16,140 feet of 54-inch and 16,600 feet of 48-inch pipe. The Connecticut River crossing is made with two 36-inch lines. The 54- and 48-inch pipe is made of 30-foot plates bent into half cylinders and are welded. The plates are sheared so that the pipe diameter increases slightly from one end to the other, permitting the small end of one section to fit into the large end of the following section.—*C. C. Ruchhoft.*

Conservation and Control of Ground Water. CHARLES CARROLL BROWN. Muni. News and Water Works, **75**: 317–8, 1928. Most of the water supplies of the cities on either the Atlantic or the Gulf coast of Florida are obtained from surface sources or from deep wells tapping limestone substrata. Some of the surface water in the state is drained by sink holes which are probably the source of the water in the lower strata of limestone. The development of the country is adding to the pollution of the surface water. Conservation and protection of the underground and surface water sources in the state have therefore become an important problem.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Water Purification and Softening Plant at Piqua, Ohio. J. M. MONTGOMERY. Muni. News and Water Works, **75**: 135–139, 1928; Public Works, **59**: 341–345, 1928. The water filtration and softening plant includes aërators, dry chemical feed devices for alum and lime, mixing tanks, a Dorr clarifier, settling basins, carbonation chambers, filters, clear well and chlorine disinfection apparatus, and has a rated capacity of 5 m.g.d. The treated water passes to the Dorr clarifiers before entering the settling tanks and operating data show that an average of 97 per cent of the sludge is removed in the clarifier. Softening is accomplished by overtreatment with lime to precipitate practically all of the magnesium and recarbonization with CO_2. The practice at Piqua is to control the lime feed exactly in a newly developed feed machine to produce an excess causticity of 40 p.p.m. After settling, the water is recarbonated until the total alkalinity to methyl orange minus two times the caustic alkalinity to phenolphthalein is equal to five. The water is then filtered and a filtered water of from 20 to 25 p.p.m. alkalinity with a total hardness of 50 to 55 is produced. The cost of this treatment is but slightly more than ordinary lime softening.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Water Consumption in England. Anon. Public Works, **60**: 86, 1929. It is pointed out that the comparison between American consumption figures and the low figures of 10 to 20 gallons per capita in England is unreasonable. This

is because American-born citizens would not tolerate the conditions that make these low figures possible. These conditions include only one faucet in an entire residence, no provision for hot water, probably no water closet, and certainly no bath tub.—*C. C. Ruchhoft.*

Pollution of Streams in Illinois. Illinois State Water Survey Bulletin, 24: 1927. This report, prepared in coöperation with the State Department of Conservation, contains information on pollution in each drainage basin by sewage and industrial wastes. The data are both summarized according to counties and also presented in the form of spot maps according to drainage areas.—*A. M. Buswell.*

The Disposal of the Sewage of the Sanitary District of Chicago. Illinois State Water Survey Bulletin 23: 1927. Alvord, Burdick and Howson. This bulletin is a publication of a report by Alvord, Burdick and Howson, consulting engineers of Chicago, by order of the Secretary of War and submitted to the District Engineer, United States Engineer Office, Chicago. It discusses in detail the amount and type of purification required for Chicago sewage, assuming various diversions of water from Lake Michigan, to safeguard the city's water-supply and to preserve fish-life in the Illinois River. As a basis for the conclusions reached, quantities of valuable scientific data have been compiled.—*A. M. Buswell.*

NEW BOOKS

A Study of Centrifugally Cast Pipe (Metal-Mold Process) Versus Sand-Cast Pipe. F. N. Menefee and A. E. White. Department of Engineering Research, University of Michigan, Ann Arbor. Pamphlet. Reprint Series No. 4, August, 1928. 37 pp. Fifty cents. This pamphlet is an authorized reprint from the Copyrighted Proceedings of the American Society for Testing Materials, 28, II, 1928. It is a report of an investigation made to determine the relative merits of sand-cast pipe and pipe centrifugally cast in metal molds. The conclusions were based on the results of physical, chemical and metallurgical tests on 48 samples of pipe from the stock yards of the Detroit Water Board. The type of tests made, their relative importance and the authors conclusions are:

TESTS	IMPORTANCE OF TESTS	FAVOR
Tension	Primary	Centrifugal
Variation in thickness	Primary	Centrifugal
Removal of strains	Primary	No decision
Impact	Primary	Sand cast
Radial compression	Primary	Sand cast
Radial deflection	Secondary	Centrifugal
Transverse	Secondary	Sand cast
Inside smoothness	Secondary	Centrifugal
Cutting	Secondary	Centrifugal
Metallographic	Secondary	Centrifugal
Hardness	Secondary	Sand cast
Chemical	Secondary	No decision

The pamphlet also includes discussions of the paper.—*R. L. McNamee.*

Gespannte Wässer. HERMANN KELLER. Wilhelm Knapp, Halle (Saale), Germany. 90 pp. 1928. A brief treatise on artesian water or "Gespanntes Wasser," which is defined as water that is confined under pressure below relatively impermeable (Wasserstauende) beds; and which is subdivided into "Ueberflurgespanntes Wasser," which will rise above the surface, and "Unterflurgespanntes Wasser," which will rise above the ground-water level (Grundwasserstand) of the vicinity but not to the surface. This paper includes a brief history of artesian water developments and theories, a classification of ground waters, with definitions; a discussion of the source and theory of artesian water, the laws of artesian flow, and influence on artesian flow of temperature, atmospheric pressure, precipitation, leaks in well casings, mineral content of the water, interference of wells, pressure of surface water and tides, and presence of gas in the water. The paper closes with a discussion of law in relation to artesian water in Germany and other countries including the United States, and makes a strong plea for the conservation of artesian water and legal protection of those who make artesian-water developments.—(*From review by O. E. Meinzer*) *David G. Thompson.*